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DRAFT

EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING REPORT

Willow Creek Daylight Project

EDMONDS, WASHINGTON

March 11, 2019

Shannon & Wilson No: 21-1-12588-050

SHANNON & WILSON

Submitted To: City of Edmonds
Public Works Department
City Hall, 2nd Floor
121 5th Avenue N
Edmonds, WA 98020
Attn: Mr. Zach Richardson

Subject: DRAFT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING REPORT, WILLOW CREEK DAYLIGHT PROJECT, EDMONDS, WASHINGTON

Shannon & Wilson prepared this report and participated in this Project as a subconsultant to the City of Edmonds. Our scope of services was specified in Agreement Number 5940 with the City of Edmonds dated December 18, 2012, and amended on November 1, 2016. This report presents Willow Creek Daylight, Expanded Marsh Alternatives Concept Design and Modeling and was prepared by the undersigned.

We are pleased to have the opportunity to assist you with this Project. If you have questions about the contents of this letter, please contact me at (206) 695-6885.

Sincerely,

Shannon & Wilson, INC.

03/11/19

David Cline, PE, CFM
Vice President - Hydraulic Engineer

CBB:CMH:DRC/drc

EXECUTIVE SUMMARY

This report presents the hydraulic assessment of the Willow Creek daylight channel alternatives. The City of Edmonds is proposing daylighting Willow Creek as part of the Edmonds Marsh Restoration Project. The daylighting and marsh restoration Project will provide access to non-natal juvenile Chinook, and other salmon species, for rearing and foraging during critical out-migration periods and locations.

This study evaluates the Daylight channel alignment with channel habitat modifications and the Project performance under extreme tide conditions and sea level rise (SLR) conditions. The results of the study found that a sinuous channel, with a low flow habitat channel, large woody debris (LWD), and wetland and riparian buffers provides beneficial habitat for juvenile salmon meeting fish-passage (accessibility) criteria, as well as providing instream and marsh connectivity habitat functions.

The study results for flood risks from the Daylight channel found that extreme King tides, storm surges, and future SLR conditions may increase flooding along the BNSF Railway, Harbor Square, and SR-104 as a result of Daylight Project. The study evaluated the Daylight Project channel without flood protection measures, with flood berms and floodwalls, and tide gate structures. We found that the Daylight channel will require flood protection berms (or floodwalls) and will ultimately reduce flood risks compared to existing conditions.

The study findings recommend daylighting Willow Creek as part of the greater Edmonds Marsh restoration. The Project should include a sinuous tidal channel, composite low-flow channel with wetland benches, LWD, and robust wetland and riparian buffers. The study recommends adding flood protection measures of flood berms or floodwalls along the BNSF Railway, Harbor Square, and SR-104 areas.

In addition, the study found water and sediment quality issues in the marsh needing attention. Additional action, such as sediment remediation and fecal coliform source studies, are recommended to restore and improve the marsh health and ecosystem functions.

Overall, the Daylight Project will provide significant benefit to juvenile Chinook salmon and other salmonid species as part of the Edmonds Marsh restoration Project. The Project cost estimate range is $13.6 to $16.6M. The Project is a major undertaking by the City and will necessitate leadership, partnerships, and significant funding resources to meet the challenges of estuary and stream restoration of a unique and special resource in an urban setting.

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ACRONYMS

2D	two-dimensional
AEP	Annual Exceedance Probability
cfs	cubic feet per second
City	City of Edmonds
FIPS	Federal Information Processing Standard
HAT	high astronomical tide
HDPE	high-density polyethylene
HEC-RAS	Hydrologic Engineering Center River Analysis System
LiDAR	light detection and ranging
LWD	large woody debris
mm	millimeters
NAD	North American Datum
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
RCP	reinforced concrete pipe
ROW	right-of-way
SLR	sea level rise
SR	State Route
SRFB	Salmon Recovery Funding Board
SVOCs	semi-volatile organic compounds
Unocal	Union Oil Company of California
USACE	U.S. Army Corps of Engineers
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
WSEL	water surface elevation

1 INTRODUCTION

This report presents the hydraulic assessment of the Willow Creek daylight channel alternatives. We have provided our services in general accordance with the Supplemental Contract Agreement #5940 Supplemental Agreement No. 2, signed November 1, 2016.

2 SITE AND PROJECT DESCRIPTION

Willow Creek and Shellabarger Creek flow from the south and east to the west through residential Edmonds, Washington (the City) (Figure 1). The two streams reach a confluence at the Edmonds Marsh (the marsh) and are joined by local stormwater system outfalls from State Route (SR-) 104, the Harbor Square commercial development, and the Point Edwards residential development to the south. The marsh historically connected to the Puget Sound through an open channel near Brackets Landing and later near the location of the Port of Edmonds Marina. As the surrounding area has developed, the channel was piped along Admiral Way to an outfall at Marina Beach Park (Figure 2).

The City has completed a feasibility study concerning the daylighting of Willow Creek downstream of the marsh through land owned by Union Oil Company of California (Unocal) with plans to transfer the property to the Washington State Department of Transportation (WSDOT) for the Edmonds Crossing Project (Shannon & Wilson, 2015). The feasibility study's preliminary daylight alignment is a continuation of the straight portion of the existing channel to a crossing beneath the BNSF Railway Company tracks at a bridge, then through the Marina Beach Park (Figure 3). These daylighting efforts will re-introduce tidal flows to the marsh, increasing beneficial flushing and promoting connectivity for non-natal juvenile salmon habitat, among others.

For this study, the City and grant agencies are exploring an expanded restoration footprint. The original feasibility study concept design Daylight channel, Alternative 1 in this report, was a straight channel constrained by the BNSF right-of-way (ROW) to the west and the future Edmonds Crossing WSDOT ferry crossing to the east on the Unocal property. The City has contracted Shannon & Wilson to evaluate a more sinuous daylight channel alignment through the Unocal property which is the planned location fo the WSDOT Edmonds Crossing ferry parking areas. The goal of the additional hydraulic modeling studies is to analyze available increases in habitat restoration area and effects of a more sinuous channel on velocity, depth, and inundation areas within the marsh. This analysis of a larger restoration footprint also involves a fish habitat study, quarterly water and annual soil and sediment sampling in the potential expanded area, and sampling of the existing channel for benthic macro-invertebrates to inform the design phase. This report concerns the extended daylight grading, wetland habitat increases, cost estimate updates, and hydraulic analysis.

3 SCOPE OF SERVICES

Our scope of services includes performing a hydrologic and hydraulic (drainage) study to evaluate the potential effects from daylighting Willow Creek via an expanded restoration alternative. The draft drainage study tasks include:

- Develop a conceptual expanded restoration plan (Selected Alternative) with input from the City Public Works and Parks department and the Project team hydraulic engineer, wetland scientist, and fish biologist.
- Develop an alternative description, grading plan, cost estimate, and calculation of habitat area increase for the Selected Alternative compared to the alternative described in the feasibility study.
- Perform hydraulic modeling of the Selected Alternative and provide depth, velocity, and inundation information.
- Provide a fish habitat summary of the Expanded Marsh Restoration Alternatives using the hydraulic modeling results (memo to be provided at a later date).

4 EXPANDED MARSH DESIGN ALTERNATIVES

Shannon & Wilson, in conjunction with the City, developed three initial concept daylight channel alternative alignments and plans for review and comment by WSDOT Ferries. These three alternatives were developed to expand upon the original straight daylight alignment in the Feasibility Study. A goal of this study, and requirement of the Salmon Recovery Funding Board (SRFB) grant, was to evaluate a sinuous channel planform and the improved habitat benefits to fish. The original daylight alignment is straight and follows the west side of the Unocal property parallel to the BNSF Railway. Alternatives 1 through 3 lay out the original daylight alignment (Alternative 1) and additional plans with increased sinuosity with riparian buffers of differing widths (Figure 3-5).

A current constraint on the Project site, at the time of this report's scope of services and contract period, are the plans by WSDOT Ferries to use Unocal property for the future Edmonds Crossing location. Unocal will transfer the property to WSDOT Ferries upon completion of the remedial investigation and site cleanup. Adding daylight channel sinuosity and riparian buffers will widen the Project footprint and encroach into areas shown on the WSDOT Ferries Edmonds Crossing plan having future structures, parking, drop-off lanes, and stormwater infrastructure.

For these reasons, City staff and Shannon & Wilson met with WSDOT Ferries on November 8, 2017, to present the revised daylight Alternatives 1 through 3 below. WSDOT Ferries staff provided feedback regarding an acceptable daylight channel and riparian buffer configuration within the context of the future Edmonds Crossing Project. Alternative 4 was developed based on the feedback from WSDOT Ferries and City staff at the meeting and is described further below.

Having agreement by WSDOT Ferries on the Project plan is an important step for the Project. The SRFB is requiring the City to provide a Memorandum of Understanding for WSDOT Ferries as the eventual landowner for working with the City to develop the daylight Project. The SRFB will not continue funding the Project until this agreement is in place.

We note that the daylight alternative alignment and grading plans described below can, and will, be modified in future final design and permit phases of the Project. These adjustments in the plans are anticipated based on the results of the hydraulic model and geomorphic assessments, conditions of permits, technical feedback from the granting agencies, and most importantly, feedback from the City staff, Council, and the Community of Edmonds.

4.1 Initial Daylight Alternatives 1 through 4

The initial daylight Alternatives 1 through 3 were presented by the City to WSDOT Ferries below. As an outcome of the meeting, WSDOT Ferries provided comments regarding parking area and stormwater pond footprint impacts, for which Alternative 4 was then developed to perform the comparative hydraulic modeling analysis with Alternative 1.

- **Alternative 1** – Straight daylight channel (Figure 3)
  - Straight tidal channel planform (1,909 feet, 2.59-acre channel)
  - Low sinuosity (one meander bend)
  - Parallel to and abutting the BNSF Railway property at top of west bank
  - 2.45-acre riparian buffer (in WSDOT Ferries area)
    - Zero buffer width to the west, zero acres (BNSF Railway)
    - 97-foot-wide average buffer width to the east, 2.45 acres (WSDOT Ferries)
  - Minimum footprint impacting the WSDOT Ferries plan

- **Alternative 2** – Sinuous daylight channel through middle of stormwater pond with moderate riparian buffer (Figure 4)
  - Sinuous tidal channel planform (length 2,066 feet, 3.21-acre channel and stormwater pond restoration)
  - Higher sinuosity (six meander bends)
  - Offset from BNSF Railway
  - 4.93-acre riparian buffer (in WSDOT Ferries area)
    - 89-foot-wide average buffer width to the west, 2.70 acres (BNSF Railway)
    - 77-foot-wide average buffer width to the east, 2.37 acres (WSDOT Ferries)
  - Channel through and restoring 1.45 stormwater pond area as wetlands (WSDOT Ferries)
  - Moderate footprint impacting the WSDOT Ferries plan
- **Alternative 3** – Sinuous daylight channel through middle of stormwater pond with the largest riparian buffer (Figure 5)
  - Sinuous tidal channel planform (length 2,032 feet, 3.31-acre channel and fill of stormwater for shallow marsh area)
  - Moderate sinuosity (four meander bends)
  - Partially offset from BNSF Railway
  - 8.33-acre riparian buffer (in WSDOT Ferries area)
    - 75-foot-wide average buffer width to the west, 2.24 acres (BNSF Railway)
    - 200-foot-wide average buffer width to the east, 6.00 acres (WSDOT Ferries)
  - Channel through and full habitat restoration of stormwater pond area (WSDOT Ferries)
  - Maximum footprint impacting the WSDOT Ferries plan
- **Alternative 4** – Sinuous daylight channel with connection west of the stormwater pond and moderate riparian buffer (Figure 6)
  - Sinuous tidal channel planform (length 2002 feet, 1.79 acres and stormwater pond connection as wetland restoration area)
  - High sinuosity (six meander bends)
  - Partially offset from BNSF Railway
  - 4.32-acre riparian buffer (in WSDOT Ferries area)
    - 25-foot-wide average buffer width to the west, 0.78 acres (BNSF Railway)
    - 135-foot-wide average buffer width to the east, 3.53 acres (WSDOT Ferries)
  - Channel connection on west side of stormwater pond with wetland restoration in pond area

- Moderate footprint impacting the WSDOT Ferries plan

Each of the alternatives above used the Typical Daylight Channel Section Without Habitat Benches as shown in Figure 7. More complex channel geometry for habitat purposes was analyzed in the subsequent, Modified Alternative, modeling studies. The initial daylight cross section includes excavation of 15 feet bottom width and approximate 50 feet top width channel with 2 Horizontal to 1 Vertical (2H:1V) side slopes. Excavation of native and fill material along the alignment with backfill of clean fill over a high-density polyethylene (HDPE) liner (as an option for potential contaminated zones), with streambed materials, topsoil import, riparian, wetland marsh, and streambank plantings.

Each of the alternatives above has identical upstream tidal channel excavations in the central area of Edmonds Marsh with invasive species treatment actions as part of the marsh restoration plan.

The Project hydraulic modeling and fish habitat benefits of Alternatives 1 and 4 are described in Sections 5 and 6 below. Shannon & Wilson submitted a report to the City in September 2016 and Confluence Environmental in December 2017 that outlines the modeling and fish habitat results for Alternatives 1 through 4. The results of these analyses were used to inform development of the Modified Alternatives 5 through 7 described in the following report section. A few key findings were as follows:

- Both Alternatives performed similarly for the daylight channel and marsh hydraulics
- Flooding for the alternatives occurs to the north from Shellabarger (Stella's) Marsh, similar to existing conditions
- Flood overtopping of the Harbor Square Berm and the BNSF Railway did not occur for the hydrology and tidal boundary conditions modeled. The tidal and stormwater flood water surface elevation (WSEL) of 12.0 feet provided only 0.1-foot of clearance at certain low points along the Harbor Square berm and the BNSF Railway; larger tidal events would likely be worsened for the Daylight Channel Project compared to existing conditions.
- Alternative 4 daylight channel sinuosity, length and complexity would provide better habitat for fish. Additional complexity through benching and LWD would improve fish habitat conditions.
- Alternative 4 riparian conditions are minimal to the north (and west) and could be expanded and improved to increase the buffer width along the BNSF Railway.
- Water quality sampling performed by Shannon & Wilson (2019) indicates moderately acceptable water quality conditions with a few exceptions. Certain water quality samples showed exceedances for fecal coliform, low dissolved oxygen, and lead. Water and sediment quality samples at WC-03 are problematic, having low dissolved oxygen

and sediment samples with volatile organic and semi-volatile organic compounds (SVOCs), including diesel and gas range organics and polyaromatic hydrocarbon compounds. These water and sediment quality conditions should be addressed by the City as part of the restoration Project and their ongoing stormwater program.

- For fish passage, the daylighting of Willow Creek will provide juvenile Chinook and other fish species unobstructed access into the Edmonds Marsh system for the first time in many decades. In doing so, the proposed restoration will provide access and suitable habitat for juvenile Chinook salmon to support their rearing and growth. Of the two alternatives evaluated, Alternative 4 would provide more and better habitat conditions than Alternative 1. The sinuosity of Alternative 4 and expanded channel areas and vegetated riparian corridor would provide substantially better habitat than Alternative 1.

4.2 Modified Daylight Alternatives 5 through 7

Three additional modeling alternatives were developed to address the concerns stated in the previous report section, and to improve fish habitat and flood conditions for the Project Alternatives 5 through 7. To start, each of the modified Project Alternatives tidal channel cross sections were updated with a low-flow habitat channel and wetland benches with placement of LWD throughout the channel to increase channel complexity, hydraulic roughness and energy dissipation, and improve forage and habitat conditions for juvenile fish (Figure 7 – Typical Daylight Channel Section – With Habitat Benches and Large Woody Debris). These modifications provide increased low-flow depths and reductions in tidal channel velocities, with cover for rearing and foraging, that benefit fish habitat conditions.

The second aspect of the modifications was related to evaluation of extreme tides, king tides and tidal storm surge and future SLR conditions, which is described in more detail in Section 5, Hydraulic Modeling, below. The concern with the Daylight Project is that the current drainage system has a tide gate and smaller culverts that either block, or substantially attenuate (reduce) tidal inflows into and water elevations in the marsh when the tide gates are open. With the future Daylight tidal channel, attenuation effects will not occur, and extreme tidal conditions could increase flood impacts along SR-104, Harbor Square, and the BNSF Railway. In our modeling analysis described below, we found that SLR conditions cause flooding along the Daylight channel and along the Port of Edmonds and City's waterfront seawall. To evaluate the effects of the Daylight channel Project separately, we assumed that the City will modify and increase the height of the seawall in the future to accommodate SLR as a separate Project from this Daylight project. This assumption allows us to delineate the flood effects of the Daylight Channel project from flooding that occurs from overtopping of the seawall.

The Modified Daylight Alternatives 5 through 7 below address these fish habitat and tidal extreme flood conditions, as described below:

- **Alternative 5** – Sinuous daylight channel with connection west of the stormwater pond and moderate riparian buffer, no flood berms, floodwalls, or tide gates/floodgates similar to previous Alternative 4 (Figure 8)
  - Revised Daylight tidal channel geometry with a low-flow habitat channel, marsh benches, and LWD.
  - Raise seawall along Port and City waterfront assumed to take place in the future.
  - Sinuous tidal channel planform (length 1,945 feet, 2.84 acres, and 1.31 acre stormwater pond connection as wetland restoration area)
  - High sinuosity (six meander bends)
  - Partially offset from BNSF Railway
  - 4.92-acre riparian buffer (in WSDOT Ferries area)
    - 25-foot-wide average buffer width to the west, 0.74 acres (BNSF Railway)
    - 135-foot-wide average buffer width to the east, 4.18 acres (WSDOT Ferries)
  - Channel connection on west side of stormwater pond with wetland restoration in pond area
  - Moderate footprint impacting the WSDOT Ferries plan
- **Alternative 6** – Sinuous daylight channel with connection west of the stormwater pond and moderate riparian buffer, similar to Alternative 4, with floodwalls/berms (Figure 9)
  - Revised Daylight tidal channel geometry with a low-flow habitat channel, marsh benches, and LWD
  - Raise seawall along Port and City waterfront assumed to take place in the future
  - Floodwall/flood berms along BNSF Railway, SR-104 areas to prevent tidal storm surge and SLR flooding
  - Sinuous tidal channel planform (length 2,008 feet, 2.74 acres, and 1.31 acre stormwater pond connection as wetland restoration area)
  - High sinuosity (six meander bends)
  - Partially offset from BNSF Railway
  - 4.28-acre riparian buffer (in WSDOT Ferries area)
    - 10-foot-wide average buffer width to the west, 0.12 acres (BNSF Railway)
    - 135-foot-wide average buffer width to the east, 4.16 acres (WSDOT Ferries)
  - Channel connection on west side of stormwater pond with wetland restoration in pond area
  - Moderate footprint impacting the WSDOT Ferries plan

- **Alternative 7** – Sinuous daylight channel with connection west of the stormwater pond and moderate riparian buffer, similar to Alternative 4, with self-regulating tide gate / flood gate (Figure 9)
  - Revised Daylight tidal channel geometry with a low-flow habitat channel, marsh benches, and LWD.
  - Raise seawall along Port and City waterfront assumed to take place in the future.
  - Floodgate/tide gate with self-regulating control set at closure elevation of 10 feet to allow regular tidal flows and prevent extreme tides into the marsh area.
  - Floodwall/flood berms along SR-104 to Dayton Street areas to prevent tidal storm surge and SLR flooding.
  - Sinuous tidal channel planform (length 1,925 feet, 2.84 acres, and 1.31 acre stormwater pond connection as wetland restoration area)
  - High sinuosity (six meander bends)
  - Partially offset from BNSF Railway
  - 4.92-acre riparian buffer (in WSDOT Ferries area)
    - 25-foot-wide average buffer width to the west, 0.74 acres (BNSF Railway)
    - 135-foot-wide average buffer width to the east, 4.18 acres (WSDOT Ferries)
  - Channel connection on west side of stormwater pond with wetland restoration in pond area
  - Moderate footprint impacting the WSDOT Ferries plan

5 HYDRAULIC MODELING

The Shannon & Wilson Willow Creek Daylight Feasibility Study (2013) utilized one-dimensional hydraulic modeling in the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) 4.0 program (Anchor QEA, 2015). For this Willow Creek Daylight Expanded Marsh Concept Design and Hydraulic Modeling Report, we developed a new HEC-RAS2D (U.S. Army Corps of Engineers, 2016) model.

5.1 Terrain

The Initial Daylight Alternatives 1 and 4, HEC-RAS 2D model, utilizes light detection and ranging (LiDAR) data from 2004, 2008, and 2012 combined with topographic survey at the site. Grid cells for calculations and visualization were spaced evenly through the two-dimensional (2D) modeling area at a 10-foot by 10-foot resolution. All data was set to horizontal coordinate system North American Datum (NAD) 1983 StatePlane Washington

North Federal Information Processing Standard (FIPS) 4601 (U.S. Feet) and vertical coordinate system North American Vertical Datum of 1988 (NAVD88).

We updated the terrain with current LiDAR to better analyze extreme tide and SLR conditions along the Edmonds waterfront seawall area. The modeling terrain was updated for Alternatives 5 through 7 using a combination of 2014 and 2016 LiDAR, 2008 and 2015 topographic field survey. Terrain grids utilize a cell size of 1 foot horizontal and 1 foot vertical. All data was set to horizontal coordinate system NAD 1983 StatePlane Washington North FIPS 4601 (U.S. Feet) and vertical coordinate system NAVD88.

5.2 Geometry

Grading plans and surfaces for the two Initial Daylight Alternatives 1 and 4 hydraulic models were developed using AutoCAD Civil3D and then exporting the surfaces geographic information system. Grading was developed for the daylight channel, stormwater pond and connections, and the tidal channel excavations and stream connections farther upstream in Edmonds Marsh.

These grading surfaces were imported into the HEC-RAS RAS mapper application and were combined with LiDAR survey data from 2004, 2008, and 2012 terrain described above. The 2D modeling grid area was expanded from the feasibility study limits to include the Marina Beach Park, the Unocal property, and the entire Edmonds Marsh and Shellabarger Creek Marsh (Stella's Marsh) west of SR-104.

The system of stormwater culverts and tide gates downstream of the existing Willow Creek channel were modeled using survey and as-built data provided by the City and as described in the feasibility study (Shannon & Wilson, 2015). For the Existing Conditions model, the tide gate is located in the stormwater pipe and vault system in the Marina Beach Park parking lot. The tide gate is allowed to operate as a normal flap gate (opening/closing with the tide) from November through March. From April through October, the tide gate is chained open.

The following is a list of culvert sizes and locations used in the existing conditions geometry.

- Two 72-inch by 48-inch corrugated metal pipe arches beneath SR-104 (also in proposed alternatives).
- One 24-inch reinforced concrete pipe (RCP) beneath berm upstream of BNSF Railway (Note: The 36-inch culvert at this location is gated shut year-round.)
- Two 42-inch RCP beneath BNSF Railway leading to Admiral Way (Port of Edmonds).

- One 42-inch composite culvert from Admiral Way to the tidal outlet with a tide gate.

The modeling extents and geometry for the Modified Daylight Alternatives were re-configured to capture the expected flood extents of extreme tides and year 2100 SLR tidal boundary conditions. This included extending the modeling grid area to include the Port of Edmonds along the seawall north toward the current-day WSDOT Ferry dock and Brackett's Landing to capture tidal flooding and overtopping of the Port of Edmonds and City's waterfront seawall. This was necessary to differentiate the flood effects from SLR overtopping of the waterfront seawall and tidal flooding derived from the proposed Project Daylight channel.

Hydraulic structures such as culverts and gates were modeled within the defined storage area/2D connectors. Culvert data was entered based the previous HEC-RAS2D model and updated using a combination of 2015 survey and data obtained from the Dayton Street and SR-104 Storm Drainage Alternatives Study (SAIC, 2013).

A Manning's roughness coefficient shapefile was created for existing conditions based on recent aerial imagery. The alternatives used a modified Manning's roughness coefficient shapefile that incorporated the daylight channel. Within the daylight, the roughness coefficients alternated between regular channel and partially blocked areas to simulate LWD installations within the channel for natural juvenile salmon habitat.

5.3 Hydrology

Hydrologic inputs for both the Initial Daylight Alternatives 1 and 4 and the Modified Alternatives 5, 6, and 7 are described in this section of the report.

5.3.1 Hydrologic Boundary Conditions for Initial Daylight Alternatives 1 and 4

The hydrology inflows to the Project Daylight channel and Edmonds Marsh modeling domain include upstream flow sources from Shellabarger Creek and Willow Creek, stormwater inputs from Point Edmond, and the WSDOT SR-104 overflow. Downstream hydrologic boundary conditions are tidal conditions of the Puget Sound. These hydrologic inflows and boundary conditions were used with high tides under current conditions and SLR conditions for year 2100 to evaluate present-day and future project performance. For upstream flows, two sources of hydrologic inflows exist.

SAIC developed a watershed scale model of the marsh, stream, and stormwater system using Hydrologic Simulation Program – FORTRAN for the City's improvements at Dayton Street to the north (SAIC, 2013). This analysis provides 100-year peak flow estimates for Willow and Shellabarger Creeks, Harbor Square, and the Point Edwards stormwater inflows. For the Initial Daylight Alternatives 1 and 4, the inflow peaks from the SAIC report were applied to a Soil Conservation Service Type IA distribution and the resultant hydrographs were applied at their respective inflow locations at the edge of the HEC-RAS 2D modeling grid for both the 100-year flow or the 1% Annual Exceedance Probability (AEP) event and for the low-flow conditions.

The downstream tidal boundary condition was replicated from the Feasibility Study as the same two-week period of tidal activity, including a king tide (high astronomical tide [HAT]) of 10.7 feet NAVD88 (SAIC, 2013). In the Feasibility Study hydrology, the king tide aligns with the initial peak of the 100-year storm. We evaluated the timing of the stormwater inflow hydrograph to the timing of the crest of the HAT and the resulting tide gate closures to identify a worst-case timing condition. Flood models were run for a peak 100-year storm occurring 12 hours before the crest of the HAT. These shifted boundary conditions showed minor increases in flood elevations throughout the system compared to existing conditions.

The tidal downstream boundary condition, and SAIC upstream stream flows and stormwater peak inflow hydrographs, with a combined peak flow rate of 138 cubic feet per second (cfs), were applied to the model as unsteady-state conditions for peak flows and low-flow habitat spring juvenile fish migrations (Figures 11A and 11B).

Anchor QEA also developed a second model of stream inflows to the site. These peak stream flows are 91 cfs followed by a 12-hour period of varying flow near 72 cfs before tailing off down to a constant low flow. This peak of 91 cfs was estimated to be near the 100-year storm and 72 cfs was estimated to be an average annual storm event (Anchor QEA, 2015) (Figures 12A and 12B).

Anchor QEA developed low-flow inflows estimated at 0.8 cfs (0.5 cfs Shellabarger Creek and 0.3 cfs Willow Creek). These design events were based on previous modeling by Anchor QEA in 2007 and information in the SAIC stormwater modeling report (Anchor QEA, 2013; SAIC, 2013). The low-flow event will be almost entirely driven by tidal inflows and represents tidal inundation and wetland functions in existing and proposed conditions during late spring and early summer when non-natal juvenile salmon would be present in the system.

Shannon & Wilson modeled both the SAIC 1% AEP and the Anchor QEA 1% AEP events with a two-week downstream tidal condition period, including a HAT. The hydraulic modeling results discussed in Section 5.4 below use the SAIC 1% AEP flood event due to our higher confidence in the flow rates from the SAIC stormwater model.

5.3.2 Hydrologic Boundary Conditions for Modified Daylight Alternatives 5, 6, and 7

Several combinations of upstream inflow and downstream extreme tide and SLR boundary conditions were developed for Modified Daylight Alternatives 5, 6, and 7. The hydrologic inflow and downstream tidal boundary condition combinations are outlined below:

Downstream Tidal Boundary Conditions – Tidal stage hydrographs (WSEL vs Time) simulate downstream tidal elevations along the Daylight channel and the waterfront seawall in the model. Three tidal boundary conditions were used.

- National Oceanic and Atmospheric Administration (NOAA) 2012 – Tidal data for the Seattle, Washington, Elliot Bay (Station Identification: 9447130) gauge. The December 17, 2012 (16:00 hrs), was considered a representative observed extreme storm surge tide event, with a peak tidal elevation of 12.12 feet (NAVD88). This event was utilized to develop alternatives to flooding within the marsh and simulate the potential WSELs and velocities the different analysis nodes might experience at a worst-case scenario.
- King Tide (HAT) – This stage hydrograph was copied from the previous study HEC-RAS 5.0.3 model. It is considered the yearly HAT of 10.7 feet NAVD88 (SAIC, 2013).
- 2100 SLR – The USACE Sea Level Change Curve Calculator (2017.55) was utilized to predict possible increases in sea level by the year 2100. Using the calculator for the Edmonds Marsh location, the NOAA Low to Intermediate and USACE Intermediate SLR of 1.77 feet was selected for the Project. For our purposes, this number was rounded to 2 feet. We note that the NOAA high and USACE high predictions estimate SLR by 5 to 6.7 feet by year 2100. The tidal hydrograph elevation ordinates for the NOAA 2012 event were increased by 2 feet to produce a year 2100 SLR downstream boundary condition tidal elevation hydrograph.

Stormwater and Stream Inflow Conditions – Inflow hydrographs (flow vs time) were used to simulate the influence of hydrologic runoff excess volume discharging into the marsh. The inflow hydrograph data was utilized from the previous study and input into the HEC-RAS 2D model relatively close to the same location as the previous study. Figures 11 and 12 present the NOAA 2012 and 2100 SLR tidal boundary conditions plotted along with the 100-year (1% AEP) SAIC hydrographs.

- Willow Creek *at hatchery*
  - Low Flow – 0.68 cfs
  - 100-year (1% AEP) SAIC – 48.55 cfs
  - 100-year (1% AEP) Anchor QEA at peak – 77.27 cfs
- Shellabarger Creek *upstream of Stella's Marsh*
  - Low Flow – 0.13 cfs

- 100-year (1% AEP) SAIC – 72.84 cfs
- 100-year (1% AEP) Anchor QEA at peak – 14.77 cfs

- Dayton Street – Harbor Square Inflow *just inside marsh*
  - 100-year (1% AEP) SAIC – 7.15 cfs – *SAME AS DAYTON STREET*
- Marsh Internal with WSDOT Manhole Overflow *inside marsh*
  - 100-year (1% AEP) SAIC - 9.63 cfs – *SAME AS STORMWATER INFLOW FROM DEVELOPMENT*
- Point Edwards Stormwater System *within daylight channel*
  - 100-year (1% AEP) SAIC – 9.63 cfs
- Dayton Street *edge of mesh on Dayton Street – ONLY IN EXISTING CONDITIONS*
  - 100-year (1% AEP) SAIC – 7.15 cfs

Initial Conditions – Initial WSELs were used in the Edmonds Marsh submesh under existing conditions for the NOAA 2012 and year 2100 SLR simulations. These initial WSEL values simulate the water levels in the marsh at the time the simulation begins. The initial WSELs were calculated based on a tide-only simulation run and do not include the stream and stormwater inflow hydrographs.

Hydrograph Lag – A 12-hour lag was applied to the inflow hydrographs for the NOAA 2012 and 2100 SLR flow data for the Alternative 7 scenario. This was to allow the marsh to fill to 10 feet NAVD88, simulating tide gate closure, before the hydrograph peaks arrived from Willow Creek and Shellabarger Creek. This was necessary to simulate the worst case conditions with respect to storage volume in the marsh.

5.4 Hydraulic Modeling Results

2D unsteady-state modeling runs were created representing existing conditions and proposed conditions for Initial Daylight Alternatives 1 and 4 and the Modified Daylight Alternatives 5, 6, and 7. The Initial Daylight Alternatives analyze the 100-year storm and low-flow tidal habitat events. The Modified Daylight Alternatives analyze the 100-year storm event with King and Storm Surge tidal conditions, and low-flow tidal habitat events, including year 2100 SLR for these various boundary conditions.

5.4.1 Results for Initial Daylight Alternatives 1 and 4

2D unsteady-state modeling runs were created representing existing and proposed conditions for Alternatives 1 and 4 for each of the 100-year storm and low-flow tidal habitat events. The models predict velocity, depth, and WSELs across the site. Specific output nodes listed below were used to frame the analyses (Figure 13).

1. Downstream tidal boundary
2. Upstream of BNSF bridge
3. Upstream end of daylight channel
4. Center of marsh
5. Willow Creek, downstream of the hatchery
6. Shellabarger Creek, downstream of the culvert crossing SR 104

Comparisons of the results for each geometry at the 100-year storm and low-flow tidal habitat event are provided in Figures 14 through 23. Comparison maps of depths and velocities for the existing and selected alternative are provided in Figures 24 through 27 and Exhibits 5-1 through 5-6.

Exhibit 5-1: Spring (King) Tide with Stream Baseflows - Existing Conditions

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.00	0.02	2.45	7.55	13.13	20.8
2	Existing Conditions has no channel					
3	0.21	0.50	0.00	2.58	3.22	
4	0.00	0.02	0.00	0.00	0.06	
5	0.07	0.08	0.00	0.20	0.22	
6	0.01	0.31	0.00	2.98	3.52	

NOTES:
Existing Node 1 is north of Node 1 for both proposed conditions. Node 2 in proposed grading area only.
ft/s = foot per second

Exhibit 5-2: Spring (King) Tide with Stream Baseflows - Alternative 1

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.21	1.42	0.09	2.20	6.78	27.4
2	0.53	1.97	0.45	2.36	6.42	
3	1.10	2.83	0.00	0.90	3.80	
4	0.03	0.13	3.06	3.37	5.19	
5	0.01	0.26	0.00	0.00	0.31	
6	0.03	0.69	1.06	1.51	3.30	

NOTES:
Existing Node 1 is north of Node 1 for both proposed conditions.
ft/s = foot per second

Exhibit 5-3: Spring (King) Tide with Stream Baseflows - Low (Tidal) Flow Alternative 4

	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
Node	Average	Maximum	Minimum	Average	Maximum	
1	0.24	1.50	0.09	2.21	6.78	30.1
2	0.58	1.99	0.44	2.34	6.31	
3	0.20	1.26	0.00	0.93	3.77	
4	0.03	0.14	2.72	3.13	5.15	
5	0.01	0.22	0.00	0.00	0.28	
6	0.02	0.40	0.85	1.28	3.28	

NOTES:

Existing Node 1 existing is north of Node 1 for both proposed conditions.

ft/s = foot per second

Exhibit 5-4: 100-Year Flow Existing Conditions

	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
Node	Average	Maximum	Minimum	Average	Maximum	
1	0.00	0.00	2.51	7.62	13.19	26.6
2						
3	0.07	0.33	0.00	1.84	4.26	
4	0.00	0.15	0.00	0.08	1.24	
5	0.06	0.66	0.00	0.18	1.24	
6	0.02	0.53	0.00	3.53	4.87	

NOTES:

Existing Node 1 is north of Node 1 for both proposed conditions. Node 2 in proposed grading area only.

ft/s = foot per second

Exhibit 5-5: 100-Year Flow Alternative 1

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.23	1.57	0.08	2.20	6.78	29.3
2	0.53	2.01	0.42	2.38	6.43	
3	0.65	2.27	0.06	1.16	4.13	
4	0.05	0.90	2.93	3.26	5.19	
5	0.04	1.70	0.00	0.01	0.42	
6	0.05	1.20	1.06	1.60	3.44	

NOTES:
Existing Node 1 is north of Node 1 for both proposed conditions.
ft/s = foot per second

Exhibit 5-6: 100-Year Flow Alternative 4

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.23	1.56	0.08	2.20	6.78	31.1
2	0.60	2.08	0.38	2.33	6.33	
3	0.17	1.05	0.00	1.09	4.12	
4	0.06	0.96	2.62	3.06	5.18	
5	0.03	1.72	0.00	0.01	0.41	
6	0.05	1.20	1.02	1.43	3.44	

NOTES:
Existing Node 1 is north of Node 1 for both proposed conditions.
ft/s = foot per second

Initial Daylight Alternative hydraulic modeling results show both Alternatives 1 and 4 perform similarly for hydraulic stormwater conveyance and flood conditions with no measurable differences between Alternative 1 and 4, and results are summarize for both. Hydraulic conditions for fish habitat and fish passage are described further in Section 6. A summary of key observations from the Initial Alternatives hydraulic modeling include:

- The daylight channel Project will have flooding along SR-104 at the north end of Shellabarger (Stella's) Marsh toward the Dayton Street intersection.
- SR-104 is not overtopped for the flood conditions analyzed at the 72-inch pipe arch culvert crossings.
- Flood overtopping of the Harbor Square berm and the BNSF Railway along the northern and western edges of Edmonds Marsh did not occur. However, modeled flood water

surfaces show near overtopping of the BNSF Railway and the Harbor Square berm elevation.

- The new daylight channel will have increased conveyance to drain stormwater inflows from Shellabarger Creek, Willow Creek, Harbor Square, and the WSDOT SR-104 manhole overflow compared to existing conditions on each tidal exchange.
- The daylight channel has velocities predicted higher than 2 feet per second (ft/s) at the Marina Beach Park area, which, if deep enough, could pose public safety risks.

5.4.2 Results for Modified Daylight Alternatives 5, 6, and 7

Hydraulic model simulations were computed for the Modified Daylight Alternatives 5, 6, and 7 using the combination of hydrologic inflows and tidal boundary conditions described above in Section 5.3.2. WSELs, depth, and velocities were calculated and output from the model at the same seven output nodes as previous models.

We present detailed descriptions and hydraulic modeling figure outputs for each of the Alternative 5, 6, and 7 in the following sections of the report. The following section describes the modeling results for Alternatives 5, 6, and 7 and the various tidal/flood scenarios. Comparison figures of existing to proposed conditions for depth and velocity for each of the Alternatives 5, 6, and 7 are referenced in their respective results sections below (Figures 28 through 45). Exhibits 5-7 through 5-14 present depth and velocity hydraulic modeling numerical results and Figures 46 through 59, show existing and proposed Project velocity and depth conditions at each of the following modeling nodes.

1. Downstream tidal boundary
2. Upstream of BNSF bridge
3. Center of daylight channel
4. Upstream end of daylight channel
5. Center of marsh
6. Willow Creek, downstream of the hatchery
7. Shellabarger Creek, downstream of the culvert crossing SR 104

The following are a few key findings for the Modified Daylight Alternative hydraulic modeling results:

- **Alternative 5** – Daylight Channel with sinuosity, low-flow habitat channel, and LWD, no flood berms/floodwall and no tide gate/floodgate.
  - Alternative 5 provides beneficial increases in marsh inundation and connectivity. The low-flow habitat channel and LWD complexes increased hydraulic roughness

and flow depths and reduced channel velocities, providing improved and suitable habitat for fish.
- Alternative 5 without flood berms/floodwalls and without tide gate/floodgate increase King tide and storm surge tide condition flooding along the BNSF Railway, Harbor Square, and SR-104 and Dayton Street intersection.
- Alternative 5 is not a viable alternative as the Daylight Project, without flood protection measures, would increase and exacerbate flood conditions for extreme tide events and future SLR scenarios.

- **Alternative 6 –** Daylight Channel with meanders, low-flow habitat channel, and LWD, flood berms/floodwall and no tide gate/floodgate.
  - Alternative 6 provides beneficial increases in marsh inundation and connectivity similar to Alternatives 5 and 7. The low-flow habitat channel and LWD complexes increased hydraulic roughness and flow depths and reduced channel velocities, providing improved and suitable habitat for fish.
  - Alternative 6 with flood berms/floodwalls and without tide gate/floodgate decreases King tide and storm surge tide flood conditions along the BNSF Railway, Harbor Square, and SR-104 and Dayton Street intersection.
  - Alternative 6 is a viable alternative for the Daylight Project by providing flood protection measures thereby improving and reducing flood risks for extreme tide events and future SLR scenarios.
- **Alternative 7** – Daylight Channel with meanders, low-flow habitat channel, and LWD, select flood berms/floodwall along SR-104 and tide gate/floodgate.
  - Alternative 7 provides beneficial increases in marsh inundation and connectivity similar to Alternatives 5 and 6. The low-flow habitat channel and LWD complexes increased hydraulic roughness and flow depths and reduced channel velocities, providing improved and suitable habitat for fish. The drawback for the tide gate/flood gate is that the gates close at higher tide conditions and limit connectivity and fish passage into the marsh during higher and extreme tide events.
  - Alternative 7 without flood berms/floodwalls and with tide gate/floodgate increases King tide and storm surge tide condition flooding along the BNSF Railway, Harbor Square, and SR-104 and Dayton Street intersection. The increase in flooding over existing conditions is that the tide gates allow tidewater into the marsh up to elevation 10 feet and current operations allow the tide gate to close on the incoming tide at a much lower level, thereby providing more flood storage in the marsh.
  - Alternative 7 is not a viable alternative for the Daylight Project as the self-regulating tide gate does not provide adequate flood storage in the marsh and has impacts for fish habitat connectivity during higher and extreme tide conditions.

5.4.2.1 Alternative 5 – Meandering Daylight Channel, Connection West of the Stormwater Pond, Moderate Riparian Buffer, Complex Low-Flow Fish Habitat Channel with Large Woody Debris (LWD), No Flood Berms, Floodwalls, or Tide Gates/Floodgates

Spring (King) Tide with Late Spring Habitat Flows and SLR (Figures 28A, 28B, 29A, and 29B) – Alternative 5 shows increases in marsh inundation footprint. The additional inundation areas would provide benefit to fish habitat. We note that overtopping of the BNSF Railway property that lies lower than the tracks occurs to the north along the Harbor Square area. Depths in the main tidal channel downstream are as much as 6 feet, with the maximum depths in the marsh about 3.5 feet. Maximum velocities in the marsh are low and in the Daylight channel range from 2 ft/s up to more than 5 ft/s at the Marina Beach Park daylight outlet on the ebb tide. Peak velocities appear to occur when flow depths on the Daylight outlet are low, thereby not indicating a public safety issue. Peak velocities in the Daylight channel upstream are on the flood and ebb tides. King tides with SLR of 2 feet cause flooding of Dayton Street, Harbor Square, the BNSF Railway, and areas to the north with the new Dayton Street pump station without the presence of a floodwall or flood berm along the BNSF Railway and SR-104 areas. For inundation areas, depths, velocities, and habitat conditions, neither Alternatives 5, 6, or 7 are substantially different between the three alternatives for hydraulic performance conditions. This section provides the detailed habitat benefit description for Spring Tide with Late Spring Habitat Flows hydraulic conditions results for all the Alternatives 5, 6 and 7.

Spring (King) Tide with SAIC 1% AEP (100-Year) Flood and SLR (Figures 30A, 30B, 31A, and 31B) – Alternative 5 shows flooding similar to existing conditions as a result of King tides with a 100-year flood event. Velocity conditions are similar to the spring tide event described above. Without a floodwall or flood berm along the BNSF Railway and SR-104, the King tide with 100-year flood event and SLR would increase flooding of the Dayton Street/SR-104 intersection, Harbor Square, and the BNSF Railway, which is an unacceptable outcome for this alternative. Additional floodwalls or flood berms are needed to prevent Daylight channel flood increases with future SLR. Alternative 5 is not a viable alternative as it causes extreme tide flooding of adjacent infrastructure and property, as a result of the Daylight Project.

Storm Surge with SAIC 1% AEP (100-Year) Flood and SLR (Figures 32A, 32B, 33A, and 33B) – Alternative 5 shows flooding similar, and slightly greater than, existing conditions as a result of storm surge tides with a 100-year flood event. Velocity conditions are similar to the spring tide event described above. Without a floodwall or flood berm along the BNSF Railway and SR-104, the storm surge tide with 100-year flood event and SLR would increase flooding of the Dayton Street/SR-104 intersection, Harbor Square, and the BNSF Railway, which is an unacceptable outcome for this alternative. Additional floodwalls or flood berms are needed to prevent Daylight channel flood increases with future SLR.

5.4.2.2 Alternative 6 – Meandering Daylight Channel, Connection West of the Stormwater Pond, Moderate Riparian Buffer, Complex Low-Flow Fish Habitat Channel with Large Woody Debris (LWD), with Flood Berms/Floodwalls, No Tide Gates/Floodgates

Spring (King) Tide with Late Spring Habitat Flows and SLR (Figures 34A, 34B, 35A, and 35B) – Alternative 6 shows increases in marsh inundation footprint. For inundation areas, depths, velocities, and habitat conditions, neither Alternatives 5, 6, or 7 are substantially different between the three alternatives for hydraulic performance conditions. Refer to Alternative 5 Spring Tide with Late Spring Habitat Flows for more detailed information on hydraulic conditions results.

Spring (King) Tide with SAIC 1% AEP (100-Year) Flood and SLR (Figures 36A, 36B, 37A, and 37B) – Alternative 6 shows substantially reduced flooding compared to existing conditions as a result of King tides with a 100-year flood event as a result of installing a flood berm/floodwall along the BNSF Railway, Harbor Square, and SR-104 areas. The portion of flooding that occurs near the SR-104 and Dayton Street intersection is from the Dayton Street stormwater inflows, which now and in the future will be accommodated by the City's new stormwater pump station planned for construction in 2019. Velocity conditions are similar to the spring tide event described above. The flood berm/floodwall structures also provide protection from SLR tidal flooding and show substantial reductions in flooded areas along the BNSF Railway, Harbor Square, and SR-104 compared to Alternative 5 in (Figure 34A vs. Figure 31A) discussed above. Again, the residual flooding in Dayton Street and Harbor Square is from Dayton Street stormwater inflows that will be handled by the new pump station.

Storm Surge with SAIC 1% AEP (100-Year) Flood and SLR (Figures 38A, 38B, 39A, and 39B) – Alternative 6 shows substantially reduced flooding compared to existing conditions as a result of storm surge tides with a 100-year flood event as a result of installing a flood berm/floodwall along the BNSF Railway, Harbor Square, and SR-104 areas. The hydraulic modeling results for storm surge condition are similar to the flood improvements for current and future SLR conditions from storm surge tide conditions with a 100-year flood event described in the previous paragraph.

5.4.2.3 Alternative 7 – Meandering Daylight Channel, Connection West of the Stormwater Pond, Moderate Riparian Buffer, Complex Low-Flow Fish Habitat

Channel with Large Wood Debris (LWD), with Select Flood Berms Along SR-104 and With Tide Gate/Floodgate

Spring (King) Tide with Late Spring Habitat Flows and SLR (Figures 40A, 40B, 41A, and 41B) – Alternative 7 shows increases in marsh inundation footprint. The floodgate would be completely open during spring tide conditions for fish habitat purposes. For inundation areas, depths, velocities, and habitat conditions, neither Alternatives 5, 6, or 7 are substantially different between the three alternatives for hydraulic performance conditions. Refer to Alternative 5 Spring Tide with Late Spring Habitat Flows for more detailed information on hydraulic conditions results. The primary difference with Alternative 7 is that the tide gate is closed at higher water levels, thereby causing a fish passage barrier in these conditions.

Spring (King) Tide with SAIC 1% AEP (100-Year) Flood and SLR (Figures 42A, 42B, 43A, and 43B) – Alternative 7 shows the floodgate closing at elevation 10 feet (NAVD88) with moderate improvements in reducing flooding compared to existing conditions for King tides with a 100-year flood event. Less flooding occurs along the SR-104 flood berm, but minor flooding does occur along the BNSF Railway leading to the Harbor Square area on the west side of the marsh. Velocity conditions are similar to the spring tide event described above. The floodgate with select flood berms along SR-104 provide reductions in flooding from SLR tidal flooding along SR-104 with some flooding occurring along the BNSF Railway leading to the Harbor Square area on the west side of the marsh. The residual flooding in Dayton Street and Harbor Square is from Dayton Street stormwater inflows that will be handled by the new pump station.

Storm Surge with SAIC 1% AEP (100-Year) Flood and SLR (Figures 44A, 44B, 45A, and 45B) – Alternative 7 shows substantially reduced flooding compared to existing conditions for storm surge tides with a 100-year flood event as a result of installing a flood berm/floodwall along the BNSF Railway, Harbor Square, and SR-104 areas. The hydraulic modeling results for storm surge condition are similar to the flood improvements for current and future SLR conditions from storm surge tide conditions with a 100-year flood event described in the previous paragraph.

We note that the Alternative 7 floodgate performance is problematic when considering the alternative flood hydrology described by Anchor QEA (2015) with a 12-hour stormwater flood peak and extended falling limb hydrograph. This type of hydrograph increases overall flow volumes filling the storage areas and causes flooding along the BNSF Railway, Harbor Square, and SR-104. The flooding from this hydrology scenario is similar to existing conditions flooding and thereby negates the intended benefit of the floodgate.

Exhibit 5-7: Low (Tidal) Flow Existing Conditions

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.01	0.07	0.00	1.86	6.32	13.4
2						
3	0.23	1.29	0.00	0.97	1.50	
4	0.00	0.00	0.00	0.00	0.00	
5	0.00	0.00	0.00	0.00	0.00	
6	0.98	1.29	0.00	0.00	0.00	

NOTES:

Node 2 in proposed grading area only.

ft/s = foot per second

Exhibit 5-8: Low (Tidal) Flow Alternative 5

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	1.59	5.63	0.00	2.15	6.62	21.7
2	0.60	1.20	1.17	2.63	6.07	
3	0.50	1.97	0.00	1.88	3.35	
4	0.06	0.31	0.18	2.07	3.55	
5	0.00	0.01	0.24	2.07	3.57	
6	0.02	0.92	0.00	1.52	3.14	

Exhibit 5-9: Low (Tidal) Flow Alternative 6

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.96	5.97	0.00	2.09	6.62	21.7
2	0.59	1.19	1.17	2.63	6.07	
3	0.49	1.95	0.00	1.88	3.35	
4	0.06	0.32	0.70	2.58	4.07	
5	0.00	0.02	0.27	2.10	3.60	
6	0.03	1.07	0.00	1.57	3.20	

Exhibit 5-10: Low (Tidal) Flow Alternative 7

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	1.08	5.90	0.00	2.06	6.62	21.5
2	0.59	1.15	1.17	2.64	6.09	
3	0.50	1.84	0.00	1.90	3.32	
4	0.06	0.34	0.55	2.45	3.89	
5	0.00	0.02	0.26	2.11	3.55	
6	0.03	1.08	0.00	1.61	2.98	

Exhibit 5-11: 100-Year Flow Existing Conditions

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.01	0.07	0.00	1.99	6.52	35.9
2						
3	0.30	1.37	0.00	1.51	3.72	
4	0.00	0.11	0.00	0.05	0.87	
5	0.08	0.42	0.00	0.05	0.41	
6	0.83	0.94	0.00	4.42	4.65	

NOTE:
Node 2 in proposed grading area only.

Exhibit 5-12: 100-Year Flow Alternative 5

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	1.87	6.58	0.00	2.11	6.62	37.3
2	0.62	1.44	1.18	2.76	6.10	
3	0.53	1.93	0.00	2.15	4.33	
4	0.11	0.81	0.39	2.71	4.90	
5	0.01	0.06	0.17	2.40	4.57	
6	0.04	0.20	0.00	1.81	3.97	

Exhibit 5-13: 100-Year Flow Alternative 6

Node	Velocity (ft/s)	Depth (ft)

	Average	Maximum	Minimum	Average	Maximum	Maximum Inundation (Acres)
1	1.60	7.23	0.00	2.16	6.62	31.7
2	0.67	1.56	1.18	2.76	6.10	
3	0.53	1.94	0.00	2.15	4.37	
4	0.10	0.74	0.59	2.91	5.14	
5	0.00	0.03	0.15	2.36	4.59	
6	0.07	0.33	0.00	1.47	3.70	

Exhibit 5-14: 100-Year Flow Alternative 7

	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
Node	Average	Maximum	Minimum	Average	Maximum	
1	1.93	6.69	0.00	2.07	6.62	31.6
2	0.68	1.53	1.18	2.76	6.11	
3	0.53	1.81	0.00	2.17	4.35	
4	0.10	0.73	0.53	2.87	5.07	
5	0.00	0.04	0.18	2.40	4.59	
6	0.05	0.23	0.00	1.91	4.10	

6 FISH HABITAT

Paul Schlenger (formerly Confluence Environmental now with Environmental Science Associates) is a Puget Sound shoreline fish habitat expert that reviewed and provided input on the Initial and Modified Daylight Alternatives. His findings and recommendations are summarized in the following sections of the report.

6.1 Fish Habitat Conditions for Initial Daylight Alternatives 1 and 4

This evaluation of the fish habitat conditions provided by the alternatives being considered for the Willow Creek Daylighting Project focused on conditions for juvenile Chinook salmon who are listed in the Endangered Species Act as threatened and are a focus of recovery efforts throughout Puget Sound. Chinook will not spawn in a stream system such as the Willow Creek and Shellabarger Creek complex because they require larger streams and rivers (e.g., Snohomish River). However, juvenile Chinook salmon have been documented to outmigrate from their natal rivers and use the estuaries, marshes, and lower stream areas in smaller streams like those provided in Edmonds Marsh (Beamer and others, 2003; Beamer 2006; Hirschi and others, 2003). Juvenile Chinook move along the shoreline of Puget Sound and would potentially use the Edmonds Marsh during the spring and when they are of sizes typically between 2.5 and 4 inches (approximately 60 to 90 millimeters). The habitat conditions that are favorable for juvenile Chinook are similar to those of other juvenile salmon species (e.g., Coho); therefore, this evaluation can be considered indicative of benefits to juvenile salmon.

- The potential fish habitat conditions provided by the proposed alternatives were evaluated through consideration of four components:
  - **Accessibility** – ability for juvenile salmon to move into an area based on water velocity and depth
  - **Instream habitat** – quality and quantity of suitable aquatic habitats to support juvenile salmon rearing
  - **Riparian habitat** – quality and quantity of upland habitats adjacent to the instream habitats
  - **Water and sediment quality** – condition of basic water quality parameters and contaminants, as well as sediment contaminant chemistry

6.1.1 Accessibility

As noted above, the juvenile Chinook salmon that the restoration is targeting will access the marsh by moving into the daylighted Willow Creek channel from Puget Sound. Their ability to move into the restored habitats is dependent upon their swimming abilities and habitat preferences for water depth, which are both influenced by their body size.

Fish passage requirements are less clear in tidal areas compared to freshwater streams (Washington Department of Fish and Wildlife [WDFW] Water Crossing Design Guidelines (Barnard and others, 2013). The law requires that fish passage is provided at manmade barriers, such as water crossings (Revised Code of Washington (State) 77.57.030), but it is not clear how efficiently or continuous over time that passage needs to be provided (Barnard and others, 2013). In the case of the Willow Creek Daylight, the Project will remove a significant barrier that was installed by the Port of Edmonds when they rerouted the stream in the 1950s.

Questions then remain regarding the Daylight channel design and the future velocity, depth, cover, and temperature conditions. The complication of fish passage in tidal environments is that access to or through intertidal habitats is naturally intermittent because of tidal processes. In tidal environments, the exchange of water into and out of coastal marshes, lagoons, and embayments can naturally have periods of time when depths are too shallow and velocities are too fast.

Design guidelines or evaluation guidelines for providing suitable conditions for fish access have not been fully developed for tidal environments such as the Willow Creek Daylighting Project or for fish the size of the juvenile Chinook salmon entering from Puget Sound. Although not strictly applicable in tidal settings like the Willow Creek Daylight channel, the criteria established in the Washington Administrative Code (WAC) 220-110-070 for culverts in freshwater provides a basis of comparison for the anticipated fish passage conditions for the proposed alternatives. The data and fish passage criteria in the WAC closest to the expected juvenile Chinook, between 2.5 and 4 inches, that will enter the Daylight Channel are 6-inch trout. Given the larger size of the trout, they will have greater swim abilities than the smaller juvenile Chinook and can therefore be expected to be able to swim against faster water velocities than juvenile Chinook. For 6-inch adult trout, the WAC establishes a minimum depth of 0.8 foot and a minimum hydraulic drop (step) of 0.8 foot. The maximum velocity criteria are based on fish navigating various culvert lengths listed below.

- For culverts less than 100 feet in length, the maximum velocity is 4.0 ft/s,
- For culverts 100 to 200 feet long, the maximum velocity is 3.0 ft/s, and
- For culverts longer than 200 feet, the maximum velocity is 2.0 ft/s.

Barnard and others (2013) provides additional guidance on velocities in culverts related to juvenile salmon size. Barnard and others (2013) references a previous WDFW report on fish passage through culverts that recommended design criteria for juvenile salmon greater than 2.4 inches (60mm) to be 1.3 ft/s (Powers and Bates, 1997). This is approximately the size that juvenile Chinook potentially entering the restoration site will be. The Powers and Bates (1997) velocity is a recommendation that is not a codified design requirement. Barnard and others (2013) also notes that the Muckleshoot Indian Tribe reports, based on a review of ten references, that the maximum velocity for juvenile salmon passage through culverts was found to be 1.0 ft/s with a range of 0.5 to 2.0 ft/s.

The fact that these criteria were established for freshwater culverts is a significant difference from the proposed daylighted channel and marsh, because there are design elements for habitat complexity that can change generally uniform velocity conditions into a series of pools and riffles providing variable velocity conditions. The habitat complexity elements of the design will further benefit fish passage conditions with respect to fish accessibility, velocity, and depth criteria.

For this evaluation, hydraulic modeling output presented in Section 5.4.1 was analyzed for fish accessibility conditions of Alternative 1 (straight channel) and Alternative 4 (sinuous/meandering channel). Fish passage conditions were evaluated assuming typical spring freshwater flows from the two creeks (0.8 cfs baseflows) entering Edmonds Marsh and the observed tidal exchange over a 14-day period. Depth and velocity outputs were analyzed at Node 2 in the downstream end of the daylighted channel (just upstream from bridge under railroad). For spring tide and stream flow conditions, the maximum water velocities flowing out of the daylighted channel were about 2 ft/s for Alternative 1 and Alternative 4. In both alternatives, the minimum depths were predicted to be 0.4 foot and water depths were predicted to be less than 0.8 foot about 30% of the time.

Analyzing the depth and velocity guidelines to the model outputs for Alternative 1, during spring tide habitat conditions, we estimate fish accessibility 60% of the time where water depths will be greater than 0.8 foot and ebb velocities less than 1.0 ft/s. Performing the same analysis for Alternative 4 meandering channel, we estimate fish accessibility only 45% of the time. In this most conservative evaluation of fish passage conditions, Alternative 1 provides better fish accessibility for small fish such as juvenile Chinook salmon more frequently than Alternative 4.

A similar difference between alternatives is predicted when evaluating velocities less than 1.3 ft/s and water depths greater than 0.8 foot. Alternative 1 is predicted to meet the velocity criteria 68% of the time whereas Alternative 4 is predicted to meet the velocity criteria 54% of the time. The difference between the alternatives is greatly reduced when running the analysis with thresholds of 2.0 ft/s velocities and 0.8-foot water depths. Alternative 1 is predicted to provide those conditions during 70% of the time whereas Alternative 4 is predicted to do so 68% of the time.

Exhibit 6-1: Percent Time Providing Suitable Fish Passage Conditions Met for Flood/Ebb Tides

Criteria	Alternative 1	Alternative 2
Depth >0.8 ft, Velocity <1.0 ft/s	60%	45%
Depth >0.8 ft, Velocity <1.3 ft/s	68%	54%
Depth >0.8 ft, Velocity <2.0 ft/s	70%	68%

A portion of the time not meeting the criteria described above is during the incoming (flood) tide. We assumed that fish passage is provided at all times during a rising tide and when water depths exceed 0.8 foot and velocities are less than 1.0 ft/s, then Alternative 1 is predicted to provide suitable conditions during 67% of the time and Alternative 4 during 57% of the time.

Overall, during typical spring conditions, Alternative 1 is predicted to provide fish access during more of the time than Alternative 4. As noted earlier, both alternatives provide the opportunity to incorporate into the design instream features (e.g., large wood) that will slow velocities and improve passage conditions. The sinuosity of Alternative 4 provides more opportunities for such design features; therefore, it is expected that the fish passage conditions provided by either alternative will be nearly equivalent, especially considering Modified Daylight Alternatives that have increased channel complexity that will address low-flow depths and high-velocity conditions.

6.1.2 Instream Habitat

The quantity and quality of aquatic habitat will affect the likelihood of juvenile Chinook salmon entering the Edmonds Marsh system and potentially remaining in the system during multiple tidal cycles. The depth and velocity conditions are some of the parameters affecting the quantity and quality of habitat. These parameters were already summarized above and provide suitable conditions for juvenile Chinook salmon throughout much of the tidal cycle; therefore, this evaluation of habitat quantity and quality focuses on other aspects of instream habitat. At this early design stage of alternative development, indicators of habitat quantity are more developed than indicators of habitat quality, which are design features to be added in later design phases.

Habitat quantity can be interpreted based on the estimated channel lengths and inundated areas provided by the different alternatives. As noted above, the juvenile Chinook salmon that are expected to use Edmonds Marsh will originate in large rivers and move into the marsh as they outmigrate along the Puget Sound shoreline. The most likely habitats to be occupied by juvenile Chinook are in the entrance channel to the marsh. Since Alternative 1 is a straight channel and Alternative 4 is a sinuous channel, Alternative 4 would provide a longer channel and increased quantity of usable fish habitat.

Both alternatives will provide access to the tidal marsh habitat provided by Edmonds Marsh. Alternative 4 provides a larger inundation area due to the expanded wetland restoration area at the upstream end of the entrance channel. The expanded restoration occurs in the current stormwater pond on the south edge of the marsh and if incorporated into the Project would provide approximately 2.7 acres more habitat than Alternative 1.

The quality of aquatic habitat in the entrance channel will be strongly influenced by design elements (e.g., channel shape and size and large wood placement) that will be developed in subsequent design phases. The sinuosity of Alternative 4 will allow for substantially greater opportunities to create complex habitat that includes pools that will benefit juvenile Chinook salmon. Juvenile Chinook are expected to use pools in the Daylight entrance channel as lower-velocity areas where they do not expend as much energy, to prey upon food delivered in water exiting the marsh, and to occupy during low-tide periods when much of the marsh has drained. Alternative 1 can support some of the design elements described above but will provide less areas for these opportunity to provide complex habitat for juvenile Chinook salmon.

6.1.3 Riparian Habitat

The establishment of a vegetated riparian corridor is a significant component of the Project restoration to provide high-functioning rearing habitat for juvenile Chinook salmon. The functions of a vegetated riparian corridor along the Daylight entrance channel will include shading of the aquatic areas, input of terrestrial insects and organic matter contributing to prey base, infiltration of stormwater runoff from surrounding areas, and providing a barrier between the creek and surrounding areas that can reduce disturbances to fish.

Both alternatives provide beneficial improvements to the riparian corridor that will benefit juvenile salmon. Both alternatives include a relatively wider riparian buffer along the south and eastern margin of the Daylight entrance channel that will provide the benefits listed above. Alternative 4 has a wider average buffer width of 135 feet compared to the Alternative 1 average buffer width of 97 feet to the south. Alternative 4 has a substantially wider north (western) average buffer width of 25 feet for compared with a zero-foot average buffer width for Alternative 1. Alternative 4 provides increased quantity of riparian buffer and continuity in the buffer on both sides of the Daylight channel.

6.1.4 Water and Sediment Quality

At the time of the review of Alternatives 1 and 4 configurations, water and sediment quality sampling data were provided by Shannon & Wilson (2019) sampling events from December 2016, March 2017, and June 2017. Basic water quality parameters of fecal coliform, temperature, and dissolved oxygen and metals from seven sampling stations distributed around the marsh and contributing creeks. The initial data from these sampling events allows for some preliminary interpretation of water quality conditions. Additional sampling events from the full set of water and sediment quality sampling are described further in Section 6.2.4 below.

The initial water quality data show favorable water quality conditions throughout the marsh for all parameters with two exceptions: fecal coliform and dissolved oxygen. Fecal coliform bacteria levels that exceeded water quality criteria at multiple stations during multiple sampling events.

Dissolved oxygen concentrations were very low (<4 milligrams per liter [mg/L]) at the station located near the Harbor Square outfall (WC-03) during both the December 2016 and June 2017 sampling events. Dissolved oxygen concentrations also did not meet water quality criteria at multiple stations in June 2017.

Sediment quality sampling conducted by Shannon & Wilson in June 2017 provides data on sediment chemistry at the same stations as were sampled for water quality. The data from one station located near the Harbor Square outfall (WC-03) had concentrations of numerous SVOCs that exceeded freshwater sediment standards. Also, at station WC-03, two petroleum compounds were present in concentrations exceeding freshwater sediment standards. The SVOCs and petroleum contaminants were also documented at other sampling stations in the marsh and creeks. At stations located in Shellabarger Creek just downstream of SR-104 (WC-04) and a central marsh location (WC-05), the concentration of a subset of the SVOCs exceeded freshwater sediment standards. Multiple metals were detected at the sampling stations, but only lead was reported in concentrations exceeding freshwater sediment standards.

The sediment quality conditions have the potential to affect the prey base available to juvenile Chinook salmon. This includes potential effects to the quantity of prey available and bioaccumulation of contaminants in juvenile salmon.

The water and sediment quality conditions are the same for both alternatives. For the proposed restoration of Edmonds Marsh to achieve its goals in providing productive rearing habitat and forage base for juvenile Chinook, it will be necessary to address and remediate contaminated sediments in the marsh in the area of WC-03. We recommend continued data collection for water quality during storm events, especially first-flush portions of storm events, to better understand contaminant inputs from the contributing watersheds.

6.1.5 Summary of Fish Passage Evaluation – Alternatives 1 and 4

The daylighting of Willow Creek will provide juvenile Chinook and other fish species unobstructed access into the Edmonds Marsh system for the first time in many decades. In doing so, the proposed restoration will provide access and suitable habitat for juvenile Chinook salmon to support their rearing and growth.

Of the two Initial Alternatives 1 and 4 evaluated, Alternative 4 would provide more and better habitat conditions than Alternative 1. The sinuosity of Alternative 4 and expanded riparian buffer and corridor would provide substantially better habitat than Alternative 1. The difference in fish accessibility based on modeled future conditions is expected to be neutralized through modifications to the Daylight Channel, including the placement of instream LWD structures and a low-flow channel that will reduce velocities and increase depths suitable for juvenile Chinook passage with increased frequency. Alternative 4 provides more areas for habitat complexity improvements preferred by juvenile Chinook.

6.2 Fish Habitat Conditions for the Modified Daylight Alternatives 5, 6, and 7

Evaluation of the fish habitat conditions provided by Alternatives 5, 6, and 7 for the Willow Creek Daylighting expands on the analysis described in the previous section, evaluating the similar characteristics of accessibility, instream habitat, water and sediment quality, and flood conditions. Riparian habitat was not evaluated for these alternatives, as the riparian areas and buffer widths do not vary significantly between Alternatives 5, 6, and 7.

6.2.1 Accessibility

We evaluated accessibility for Alternatives 5, 6, and 7 using the methods previously described that consider velocity and depths for the juvenile Chinook salmon that will enter the Daylight channel and marsh during their outmigration from the Puget Sound. The following fish access observations are based on depth and velocity plots for each of the seven nodes during late spring and late spring with SLR conditions (Figures 46 through 59). Nodes 2, 3 and 4 represent conditions in the daylighted channel (entrance area) downstream of the broader marsh area. Model outputs show that with existing sea levels, all three of the Modified Alternatives 5, 6, and 7 provide sufficient water depths for juvenile Chinook throughout the entire 14-day period evaluated. Similarly, velocities into and out of the marsh are predicted to be less than 2 ft/s throughout the entire 14-day period. At node 2 just upstream of the BNSF bridge, peak velocities are predicted to be less than 1.6 ft/s in Alternatives 5 and 7 and even lower in Alternative 6. At node 3 near the midpoint of the daylight channel and node 4 at the upstream end of the daylight channel, the highest water velocities (between 1.3 and 1.8 ft/s, respectively) are during rising tides, which helps carry juvenile salmon into the marsh.

The same analysis with SLR modeling results predicts that all three alternatives provide sufficient water depths for juvenile Chinook throughout the entire 14-day period evaluated. Water velocities are predicted to be higher than in existing condition scenarios. At node 2 just upstream of the BNSF bridge, for SLR increases, peak velocities increase up to as high as 2.4 ft/s for Alternative 5 and 2.1 ft/s in Alternative 6 and 7.

In Alternative 6, the peak velocities drop more quickly than in either of the other two alternatives. At node 3 near the midpoint of the daylight channel, peak velocities are predicted to remain below 2 ft/s and those times with the highest velocities are during rising tides for which smaller fish would migrate with the tides into the marsh. Node 4 at the upstream end of the daylight channel, has predicted peak velocities exceeding 2 ft/s during brief periods associated with rising tides.

For all three alternatives, nodes 5, 6, and 7 in the marsh and creek channels are predicted to provide suitable depth and velocity conditions throughout the 14-day period. In this way, once juvenile Chinook enter the main portion of the tidal marsh, they will be able to move among its tidal channels.

Overall, all three alternatives are predicted to provide suitable depth and velocity conditions for juvenile Chinook in Puget Sound to be able to move into the marsh system. The brief periods in which outgoing velocities are predicted to exceed 2 ft/s are not that different from the naturally intermittent suitable velocities in tidal channels. Further, upcoming design refinements to include habitat complexity features such as pools and large wood should create lower velocity areas within the channel.

6.2.2 Instream Habitat

The quantity and quality of aquatic habitat will affect the likelihood of juvenile Chinook salmon entering the Edmonds Marsh system and potentially remaining in the system throughout multiple tidal cycles. The depth and velocity conditions affect the quantity and quality of habitat. These parameters, summarized above, indicate the Daylight channel will provide suitable conditions for juvenile Chinook salmon throughout much of the tidal cycle; therefore, this evaluation of habitat quantity and quality focuses on other aspects of instream habitat.

The meandering channel of all three alternatives provides more habitat and better habitat than a straighter alignment. The quality of aquatic habitat in the entrance channel will be strongly influenced by design elements (e.g., channel shape and size and large wood placement) that will be developed in subsequent design phases. The sinuosity of the alternatives will allow for substantially greater opportunities to create complex habitat that includes pools that will benefit juvenile Chinook salmon. Juvenile Chinook are expected to use pools in the entrance channel as lower-velocity areas where they do not need to expend as much energy, to prey upon food delivered in water exiting the marsh, and to occupy during low tides when much of the marsh has drained. The habitat in the daylight channel is especially important, because it is the first area encountered by juvenile Chinook entering the system and will be used by fish who ultimately do not move all the way into the broader marsh upstream of the channel.

6.2.3 Water and Sediment Quality

Water and sediment quality sampling results, for existing conditions in the marsh, were augmented with data from the September 2017 sampling event. The data provide information regarding basic water quality parameters, fecal coliform, and metals from seven sampling stations distributed around the marsh and contributing creeks. The data from these sampling events allows for some preliminary interpretation of water quality conditions.

The data show acceptable water quality conditions throughout the marsh for all parameters with two exceptions: fecal coliform and dissolved oxygen. Fecal coliform bacteria levels exceeded water quality criteria at multiple stations during multiple sampling events. In each of the four sampling events, there was at least one station with fecal coliform bacteria concentrations more than double the criteria and every station in the marsh exceeded the criteria at least two out of the four sampling events. In three of the four sampling events, the highest concentration was at a station (WC-02) in the creek channel near the existing pipe outlet draining the marsh.

Dissolved oxygen concentrations also did not meet water quality criteria at any of the stations in September 2017 and at multiple stations in June 2017. Dissolved oxygen concentrations were very low (<4 mg/L) at the station located near the Harbor Square outfall (WC-03) during the December, June, and September sampling events. In June and September, these concentrations were especially low (2.4 to 2.5 mg/l), which would be problematic for juvenile Chinook in that area. Factors contributing to the low dissolved oxygen, especially at the Harbor Square outfall, should be addressed to support efforts to restore the function of the marsh as habitat for juvenile Chinook salmon. Increased tidal exchange resulting from the Project Daylight and marsh restoration will improve dissolved oxygen conditions.

Sediment quality was previously discussed in Section 6.1.4, and the results and analysis did not change with the September 2017 sampling event results.

Macroinvertebrate sampling was conducted in September 2017 at each of the water quality sampling locations. The sampling laboratory results shows that the macroinvertebrate community composition is indicative of a site affected by pollution. Of the seven sampling locations, four were classified as "very poor" and the other three were classified as "poor" in the Benthic-Index of Biological Integrity (B-IBI). These results indicate that the prey community that would be available to juvenile Chinook salmon following restoration is not highly productive. For the proposed restoration to achieve its goals in providing productive rearing habitat and forage base for juvenile Chinook, it will be necessary to address the water and sediment quality exceedances in the marsh through stormwater best management practices, source control, and remediation of contaminated sediments.

6.2.4 Flood Conditions

In this evaluation, fish access conditions were evaluated using depth and velocity outputs from a 2D hydraulic model to characterize fish habitat during different scenarios based on combinations of peak freshwater and saltwater conditions. The freshwater inputs used in the scenarios included (1) the 1% AEP (100-year event) based on the City's stormwater runoff model by SAIC and (2) the December 2007 (AnchorQEA) 1% AEP. The tidal inputs used in the scenarios included spring (King) tides, tidal storm surge, and SLR.

Figures 24 through 45 show maximum inundation depths, inundation extents, and velocities for each Alternative 5, 6, and 7. In all scenarios, these three alternatives have large portions of the marsh providing suitable depths and velocities, thereby providing excellent spring habitat and flood refugia habitat for juvenile Chinook and other salmonids. Since depth and velocity conditions were similar across alternatives, the primary factor considered in this analysis was the extent of inundation. Throughout the scenarios evaluated, Alternative 6 consistently provided less flooding of areas beyond the marsh boundaries (i.e., the urbanized areas, including roads, parking lots, rail lines, and buildings) compared to Alternatives 5 and 7. The lesser flooding of these urban areas for Alternative 6 is considered favorable to juvenile Chinook, because it lessens the possibility of the fish moving into flooded areas beyond the marsh habitats. Such movements would expose fish to the possibility of getting stranded and increased exposure to chemical contaminants present in the flooded areas (e.g., roads and parking lots).

6.2.5 Summary of Fish Habitat Evaluation

The daylighting of Willow Creek will provide juvenile Chinook and other fish species unobstructed access into the Edmonds Marsh system for the first time in many decades. In doing so, the proposed Daylight and marsh restoration will provide access and suitable habitat for juvenile Chinook salmon to support their rearing and growth.

All three of the Alternatives 5, 6, and 7 evaluated will provide suitable depth and velocities for juvenile Chinook to access the channel and tidal marsh habitats. The main differentiation among the alternatives is the flooding extents. Alternative 6 is predicted to result in less flooding of areas beyond the marsh and will therefore have a lower likelihood of stranding and risk of exposure to chemical contaminants than Alternative 5 or 7.

The water and sediment quality sampling in the marsh indicates some impaired conditions. Addressing the factors contributing to these conditions, including targeted sediment remediation, is advised to reduce exposure and bioaccumulation risks to fish and more fully realize the fish habitat benefits of the proposed restoration. For the proposed restoration to achieve its goals in providing productive rearing habitat and forage base for juvenile Chinook, it will be necessary to address the sediment quality exceedances in the marsh through remediation of contaminated materials and source control.

Another item to consider is the lower macroinvertebrate productivity levels in the current daylight channel. Over time, it is expected that these population numbers and species composition will adjust with new tidal exchange into the marsh. Recent trends in stream restoration have included attempts to seed macroinvertebrates in streambed materials with a goal to accelerate restoration and provide food sources in the daylight channel and marsh immediately following Project implementation. We recommend consideration of macroinvertebrate seeding as a potential restoration action in the final design phase of the Project.

7 COST ESTIMATES

We prepared detailed engineering opinion of cost (cost estimates) for Alternatives 1, 4, 6, and 7 (Tables 1 through 4). Quantity takeoff estimates for the Project were developed from the grading plans, cross section and structure details, and dimensional takeoff quantities for the Project features shown in Figures 3 through 10. The following are key assumptions, results, and recommendations for the Project cost estimates:

- A cost estimate for Alternative 5 was not developed. It is the same as Alternative 4 with the differences between the alternatives being the performance of extreme tide condition hydraulic modeling for Alternative 5 and comparison to other Alternatives 6 and 7 for habitat and flood protection performance.
- The unit prices used in the cost estimates were derived from other recent fish habitat restoration projects, including Fisher Slough estuary restoration (2010 bids), Fir Island Farm estuary restoration (2016 bids), RS Means Heavy Construction Cost Data (2017), and WSDOT unit pricing bid tabs (2012). We adjusted the unit prices by providing a 10% escalation price adjustment to account for the eight years of data.
- Taxes are 10.3% on construction price.
- Bonding and insurance costs are 5% of construction.
- Construction bid and change contingencies are set at 25% of construction.
- Engineering and permit costs are estimated at 15% of the construction costs and are in addition to the construction costs.
- Construction administration is estimated at 10% of the construction costs and is in addition to the construction costs.

- Costs for Marina Beach Park are for the Daylight Channel grading and restoration areas only.
- Daylight Channel excavation assumes 50% (contingency) of the material would be contaminated above the site cleanup limit and would require off-site disposal. This is a conservative estimate being moved forward until additional environmental testing along the Daylight alignment is complete to confirm soil contamination conditions. Disposal of clean and hazardous waste costs were developed from WSDOT bid prices on local projects.
- Daylight channel restoration assumes an HDPE liner is needed to protect from contamination. This is a contingency that may be removed once environmental testing for residual contamination that may remain below the Unocal-agreed cleanup levels.
- The expanded restoration concepts in this report include earthwork volume assumptions for disposal of the liner in the Unocal stormwater treatment pond and the estimated 1 foot of sediment above it. Cost line items have also been added for the removal and disposal of the liner, sediment, and pumps within the Unocal pond, and decommissioning of five groundwater wells.
- One acre of wetland impact and mitigation costs is included along the BNSF Railway for Alternative 6A flood berm installation.
- The costs for marsh sediment remediation based on recent sediment contamination testing results and findings near the WC-03 monitoring site have not been included in this estimate. Additional sampling around the area is needed to delineate the extents, area, depth, and volume of contamination and remediation.
- Cost estimates will need to be further adjusted during final design and at the time of bid. The current estimate is for the current year 2019. We recommend an annual 3% escalation factor. If the Project is to be bid in 2021, then the Project cost estimates will increase by 6% over this 2019 cost estimate. Budgetary planning should forecast these annual escalation factors in future grant applications and capital improvement project funding requests.
- **Real estate costs are not included in the Project costs. If the City were to purchase property, rights-of-way, or easements for the Project, these costs would be in addition to the cost estimates presented in this report.**

The Project cost estimates for Alternatives 1, 4, 6, and 7 are summarized in the exhibit below. Project costs include construction costs, price escalation factors, taxes, bonding and insurance, construction contingencies, engineering and permitting, and construction administration. Real estate, rights-of-way, and easement costs are not included. The cost estimates range from $9M for Alternative 1 to $16.6M for Alternative 6B – Daylight with Floodwalls. We estimated costs for Alternative 6A (flood berms $13.6M) and 6B (floodwalls $16.6M). Flood berms may be feasible but may be more difficult to permit as the flood berms will have increased wetland impacts. Depending on wetland permitting regulations, Project funding sources, and BNSF Railway input, there may be Project regulatory and landowner drivers that could dictate which of these structures is feasible and acceptable, regardless of the Project costs.

8 CONCLUSIONS AND RECOMMENDATIONS

The expanded marsh alternatives and hydraulic modeling resulted in several new findings and recommendations regarding the Project fish habitat benefits, flood risk reductions, cost estimates, water and sediment quality conditions, and the Project design and construction considerations.

In developing the alternatives, a straight Daylight Channel (Alternative 1) and sinuous/meandering Daylight Channel (Alternatives 2, 3, and 4) were developed. Based on feedback from the City and WSDOT Ferries, Alternatives 1 and 4 were analyzed using the HEC-RAS2D model. At the time of this decision, WSDOT Ferries had/has plans for the Edmonds Crossing Project, which influences the potential size and configuration of the Daylight Channel. If the WSDOT Ferries Edmonds Crossing Project continues to move forward, the Daylight Channel will be constrained between the BNSF Railway and the WSDOT Ferries Edmonds Crossing projects and their infrastructure. If the WSDOT Ferries project does not go forward, more space would be available for the Daylight Channel to the areas south and east of the current proposed alignments. We note that the Daylight channel grading can be modified in the future based on the plans of the Edmonds Crossing project.

In review of Alternatives 1 and 4, we initially found that Alternative 1 (straight daylight channel) had more suitable conditions for fish accessibility (depth and velocity and period of time) based on the results of the preliminary hydraulic model. The results of the initial modeling analysis indicated that both Alternatives 1 and 4 had fairly frequent shallow depths and higher velocities that exceeded juvenile fish criteria. Our habitat analysis included evaluation of the quantity of stream lengths, channel pattern, riparian conditions, and other factors, and found that a sinuous channel Alternative 4 would provide increased restoration potential due to stream lengths and areas that could provide variability and complexity. Alternative 4 was recommended for additional modified alternative hydraulic modeling analysis. A finding of the initial modeling analysis was to increase complexity and roughness along the Daylight channel to improve fish habitat conditions, as well as further analysis of extreme tide events and SLR conditions.

Modified Alternatives 5, 6, and 7 were then developed with a low-flow habitat channel and LWD structures to improve channel complexity and hydraulic roughness. The result was that depth and velocity criteria were met for nearly all flow conditions, and that these alternatives provide for increases in fish habitat conditions of marsh inundation areas, accessibility, and instream habitat for all three of the Modified Alternatives 5, 6, and 7.

The differences between Alternatives 5, 6, and 7 was the performance of the necessary flood protection berms, floodwalls, and tide gate structures for both flood risk reduction and habitat conditions. We found that without these flood control structures, Alternative 5 experienced increased flooding along the BNSF Railway, Harbor Square, SR-104, and Dayton Street areas compared to existing conditions, which is an unacceptable outcome for the project. Flood protection structures are needed for the Project. Our analysis of King tides, storm surges, and SLR showed increased flooding for both Alternatives 5 and 7 compared to existing conditions, which is unacceptable and not allowed per environmental and floodplain and drainage regulations. Habitat analyses showed that these Modified Alternatives provide similar habitat functions, except for how often flooding occurs where fish might encounter roads, parking areas, and railway areas as a result of flooding. Alternative 6 outperformed the other alternatives for both habitat and flood risk criteria.

We recommend the City select Alternative 6 – Sinuous Tidal Channel with Flood Berms/Floodwalls for final design, permitting and construction. Additional discussion is needed regarding whether or not to use flood berms or floodwalls for Alternative 6, as the floodwalls are more expensive, and the flood berms have larger environmental and wetland impacts and potential mitigation requirements and costs. We understand that the City staff and City Council are interested in expanding the Daylight channel and riparian buffer footprint to the fullest extent possible. In this study, the Daylight Project footprint is constrained by the assumption that WSDOT Ferries will use the site for the future Edmonds Crossing. For current grant applications with the SRFB, WSDOT Ferries must sign a Memorandum of Understanding for additional funding to be provided. We recommend proceeding with the limited footprint shown in this study for Alternative 6. If the WSDOT Ferries site constraints are later removed, the Daylight Channel alignment can be modified in final design. The one caution with expanding the Daylight Channel is that costs will increase due to increases in excavation, fill, and potential treatment and disposal quantities, as the risks for encountering residual contamination on the site increase with any additional excavation.

Installation of the flood berm or floodwall along the BNSF Railway will require close coordination with the railway. Parts of these structures will need to lie within the BNSF Railway ROW in order to tie to high ground. BNSF Railway will require right-of-occupancy and construction general permits to make modifications and perform construction within the railway ROW. The BNSF Railway will ultimately benefit from the Project through reductions in flood risks and redesign of a segment of the railway along the western margin of the Edmonds Marsh wetlands where rail maintenance operations currently impact the marsh's wetlands.

One incidental finding from the study was that future SLR for year 2100 of about 2 feet rise in sea levels could cause substantial flooding during King tides and storm surges of the Port of Edmonds and City waterfront areas. The existing seawall does not appear to have adequate heights to provide flood protection for these areas in the future. We recommend the City begin study of retrofits for the seawall in response to climate change and current projections of SLR.

Another finding as a part of this report and study includes finding SVOC and petroleum contamination in the sediments near the Harbor Square stormwater outfall. The outfall is owned and operated by the City, providing stormwater drainage from the Harbor Square buildings and parking areas. Delineation and characterization of the contamination is needed, with development and implementation of a site remediation plan. The City should contact the Washington State Department of Ecology regarding the finding of contaminated sediments in the marsh near the City's Harbor Square stormwater outfall.

Other water and sediment quality monitoring indicates that there are fecal coliform pollutants entering the marsh and Daylight Channels, periodic low dissolved oxygen conditions, and other water quality exceedances. The sources of fecal coliform are currently unknown. We recommend a microbial source tracking analysis to determine if the sources are natural in origin, domestic pets, or human nature and to inform the best practices for addressing the source pollution.

Another source of pollution to the marsh is along the Harbor Square and WSDOT's SR-104. Water quality treatment measures in these areas should be reviewed by the City. The section of SR-104 will be part of the Project for additional flood protection measures. The differences between Alternatives 5, 6, and 7 was the performance of the necessary flood protection berms, floodwalls, and tide gate structures for both flood risk reduction and habitat conditions. Modifications to the SR-104 roadway may require adding water quality treatment measures. The two existing 72-inch pipe arch culverts beneath SR-104 are in poor condition and need to be replaced. They are not currently listed on WSDOT's fish passage program, but this condition could change with the Daylighting and Edmonds Marsh restoration Project. We recommend the City continue discussions with WSDOT roads staff to evaluate options to improve fish passage and water quality along SR-104.

The Project cost estimates range between $13.5 and $16.6M. We have not included the recommended sediment remediation costs, or real estate costs in the cost estimate. We recommend the City use these estimates for planning and grant application purposes. We also recommend the City undertake design studies to refine the uncertainty and contingencies in the cost estimate. This includes sediment contamination delineation and remediation plan for the City's Harbor Square stormwater outfall. Another important step will be gaining access to the site from WSDOT Ferries for environmental investigations along Daylight excavation and grading areas. Design negotiations are also needed with the BNSF Railway for flood protection berms or floodwall features. Similarly, WSDOT roads design negotiations will need to continue regarding SR-104 flood protection, fish passage, and water quality treatment needs.

9 LIMITATIONS

Shannon & Wilson prepared this report for the exclusive use of the City and their representatives for specific application to the Willow Creek Daylight. Our judgments, conclusions, and interpretations presented in the report should not be construed as a warranty of existing site conditions or future estimated conditions. It is in no way guaranteed that any regulatory agency will reach the same conclusions as Shannon & Wilson.

Our assessment, conclusions, recommendations, etc., are based on the limitations of our approved scope, schedule, and budget described in our contract dated November 1, 2016.

Stream and wetland systems function as a collection of integrated system components. It is not practical or possible to completely know all of the geomorphic, hydrologic, and hydraulic properties of a stream and wetland system. Consequently, uncertainty exists as to actual stream and wetland behavior, performance, and function. Regular inspections of the stream and storm drainage systems should be performed. Risks should be managed as appropriate based on observed conditions, uncertainty, and potential consequences. If conditions different from those described herein are encountered during later phases of work on this Project, we should review our description of the stream and wetland conditions and reconsider our conclusions and recommendations. Potential variation includes, but is not limited to:

- The conditions between and beyond study areas may be different.
- The passage of time or intervening causes (natural and manmade) may result in changes to site and stream conditions.
- Changes in land uses in the watershed beyond the site area.

We have prepared our recommendations for daylight alignment selection considering the information available at the time of this report. If additional information becomes available, the recommendations presented herein may need to be revised. Shannon & Wilson should be made aware of the revised or additional information so we can evaluate our recommendations for applicability.

Shannon & Wilson has prepared the enclosed, "Important Information About Your Geotechnical/ Environmental Report," to assist you and others in understanding the use and limitations of our reports.

10 REFERENCES

Anchor QEA, LLC, 2013, Tidal marsh hydrodynamics report, Willow Creek daylight early feasibility study: Report prepared by Anchor QEA, LLC, Seattle, Wash., Project Number 120017-01.01, for Shannon & Wilson, Inc., Seattle, Wash., May.

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TABLE 1
ALTERNATIVE 1
COST ESTIMATE

Item	Description	Quantity	Units		Unit Cost		Item Cost[1]		Subtotal
1.0	Mobilization and Demobilization	1	LS	$	50,000.00	$	50,000	$	50,000
2.0	Marina Beach Park (Channel and Habitat Features)								
2.1	Temporary Erosion and Sediment Control	1	LS	$	50,000.00	$	50,000		
2.2	Demolition and Removal (existing tide gate and water main)	1	LS	$	50,000.00	$	50,000		
2.3	Dewatering	1	LS	$	100,000.00	$	100,000		
2.4	Channel Excavation	8,000	CY	$	10.00	$	80,000		
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	3,900	CY	$	10.00	$	39,000		
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	3,900	CY	$	95.35	$	371,865		
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$	81.50	$	81,500		
2.6	Channel and Shoreline Habitat Features	1	LS	$	50,000.00	$	50,000		
2.7	Revegetation	1	LS	$	50,000.00	$	50,000	$	873,000
3.0	Daylight Channel Construction								
3.1	Temporary Erosion and Sediment Control	1	LS	$	50,000.00	$	50,000		
3.2	Dewatering	1	LS	$	250,000.00	$	250,000		
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$	50,000.00	$	50,000		
3.4	Channel Excavation	16,900	CY	$	7.00	$	118,300		
3.5.1	Haul and Dispose Excavated Material (uncontaminated)	13,520	CY	$	10.00	$	135,200		
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	13,520	CY	$	95.35	$	1,289,132		
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$	250,000.00	$	250,000		
3.7	HDPE Channel Liner for Contaminant Protection	84,600	SF	$	2.50	$	211,500		
3.8	Self-regulating Tide gate	1	LS	$	400,000.00	$	400,000		
3.9	Import Clean Liner Backfill	9,400	CY	$	16.20	$	152,280		
3.10	Utility Relocations	1	LS	$	25,000.00	$	25,000		
3.11	BNSF Railroad ROW Work								
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$	50,000.00	$	50,000		
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$	100,000.00	$	100,000		
3.11.3	BNSF Railroad Flagger	30	EA	$	2,000.00	$	60,000		
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$	60.00	$	15,000		
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$	60.00	$	30,000		
3.14	Soldier Pile Wall	150	LF	$	2,500.00	$	375,000		
3.15	MSE Wall Facing	750	SF	$	50.00	$	37,500		
3.16	Daylight Channel Revegetation	1	LS	$	50,000.00	$	50,000	$	3,649,000
4.0	Marsh Improvements								
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$	10,000.00	$	14,000		
4.2	Channel Excavation/Dredging	970	CY	$	50.00	$	48,500		
4.3	Haul and Dispose Excavated Material (uncontaminated)	485	CY	$	10.00	$	4,850		
4.4	Haul and Dispose Excavated Material (contaminated)	485	CY	$	95.35	$	46,245		
4.5	Marsh Habitat Features	1	LS	$	25,000.00	$	25,000		
4.6	Revegetation	1	LS	$	50,000.00	$	50,000	$	189,000
					Equipment, Labor, and Material Costs	$	4,759,872	$	4,761,000
					Escalation Adjustment (10.0%)	$	475,987		
					Taxes (10.3%)	$	490,267		
					Bonding & Insurance (5%)	$	237,994		
					Contingency (25%)	$	1,189,968		
					Construction Cost	$	7,154,087	$	7,155,000
					Real Estate Agreements, Easements, Real Property (TBD)	$	-		
					Engineering, Permits (15% of Construction)	$	1,073,113		
					Construction Administration (10% of Construction)	$	715,409		
					Project Costs	$	8,942,609	$	8,943,000

Notes:
[1] Costs are rounded to nearest thousand.
% = percent
AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

TABLE 2
ALTERNATIVE 4
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	$ 50,000
2.0	Marina Beach Park (Channel and Habitat Features)					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tide gate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	12,200	CY	$ 10.00	$ 122,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	6,100	CY	$ 10.00	$ 61,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	6,100	CY	$ 95.35	$ 581,635	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 81,500	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 1,147,000
3.0	Daylight Channel Construction					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	17,400	CY	$ 7.00	$ 121,800	
3.5.1	Haul and Dispose Excavated Material (uncontaminated)	8,700	CY	$ 10.00	$ 87,000	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	8,700	CY	$ 95.35	$ 829,545	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	90,000	SF	$ 2.50	$ 225,000	
3.8	Self-regulating Tide gate	1	LS	$ 400,000.00	$ 400,000	
3.9	Import Clean Liner Backfill	10,000	CY	$ 16.20	$ 162,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 37,500	
3.16	Daylight Channel Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 3,168,000
4.0	Marsh Improvements					
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$ 10,000.00	$ 13,659	
4.2	Channel Excavation/Dredging	9,028	CY	$ 50.00	$ 451,400	
4.3	Haul and Dispose Excavated Material (uncontaminated)	2,853	CY	$ 10.00	$ 28,530	
4.4	Haul and Dispose Excavated Material (contaminated)	6,175	CY	$ 95.35	$ 588,786	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Demo and Dispose of Pond Pump Station	1	LS	$ 50,000.00	$ 50,000	
4.7	Decommission wells	5	EA	$ 5,000.00	$ 25,000	
4.8	Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 1,233,000
				Equipment, Labor, and Material Costs	$ 5,596,356	$ 5,598,000
				Escalation Adjustment (10.0%)	$ 559,636	
				Taxes (10.3%)	$ 576,425	
				Bonding & Insurance (5%)	$ 279,818	
				Contingency (25%)	$ 1,399,089	
				Construction Cost	$ 8,411,322	$ 8,412,000
				Real Estate Agreements, Easements, Real Property (TBD)	$ -	
				Engineering, Permits (15% of Construction)	$ 1,261,698	
				Construction Administration (10% of Construction)	$ 841,132	
				Project Costs	$ 10,514,153	$ 10,515,000

Notes:

[1] Costs are rounded to nearest thousand.

% = percent

AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

Liner and contaminated sediment depth inside existing treatment pond assumed to total 1 ft.

TABLE 3A
ALTERNATIVE 6A
DAYLIGHT WITH FLOOD BERMS
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	$ 50,000
2.0	Marina Beach Park (Channel and Habitat Features)					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	12,200	CY	$ 10.00	$ 122,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	6,100	CY	$ 10.00	$ 61,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	6,100	CY	$ 95.35	$ 582,000	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 82,000	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 1,147,000
3.0	Daylight Channel Construction					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	21,100	CY	$ 7.00	$ 148,000	
3.5.1	Excavated Material (uncontaminated) for use in Parking Area Fill	10,600	CY	$ 10.00	$ 106,000	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	10,600	CY	$ 95.35	$ 1,011,000	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	107,700	SF	$ 2.50	$ 269,000	
3.9	Import Clean Liner Backfill	10,000	CY	$ 16.20	$ 162,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 38,000	
3.2	Side Slope Revegetation Topsoil Type B	2,500	CY	$ 5.00	$ 12,500	
3.2	Side Slope Revegetation Seeding and Mulching	2	AC	$ 3,600.00	$ 5,616	
3.2	Bench Plug Planting (Sedges, Hairgrass, Blurus)	20,000	EA	$ 2.00	$ 40,000	
3.2	Large Woody Debris	200	EA	$ 1,000.00	$ 200,000	$ 3,248,000
4.0	Marsh Improvements					
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$ 10,000.00	$ 14,000	
4.2	Channel Excavation/Dredging	9,028	CY	$ 50.00	$ 451,000	
4.3	Haul and Dispose Excavated Material (uncontaminated)	2,853	CY	$ 10.00	$ 29,000	
4.4	Haul and Dispose Excavated Material (contaminated)	6,175	CY	$ 95.35	$ 589,000	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Demo and Dispose of Pond Pump Station	1	LS	$ 50,000.00	$ 50,000	
4.7	Decomission wells	5	EA	$ 5,000.00	$ 25,000	
4.8	Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 1,233,000
5.0	Railroad Levee and Sheet Pile Floodwall					
5.1	BNSF Railroad ROW Work					
5.1.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
5.1.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
5.1.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
5.1.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
5.1.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
5.2	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
5.3	Levee Select Fill	9,500	CY	$ 25.00	$ 237,500	
5.4	Embankment Compaction	9,500	CY	$ 2.50	$ 23,750.00	
5.5	Side Slope Revegetation Seeding and Mulching	1	AC	$ 3,600.00	$ 3,600.00	
5.6	Side Slope Revegetation Topsoil Type B	1,600.0	CY	$ 5.00	$ 8,000	
5.7	Gravel Borrow incl Haul (9" thickness)	900	TON	$ 14.00	$ 12,600	
5.8	Wetland Mitigation from Levee Fill	1	AC	$ 750,000.00	$ 747,245	$ 1,338,000
6.0	Harbor Square / SR-104 Levee					

TABLE 3A
ALTERNATIVE 6A
DAYLIGHT WITH FLOOD BERMS
COST ESTIMATE

6.1	Temporary Erosion Control and Sediment Control	1.0	LS	$	5,000.00	$	5,000		
6.2	Levee Select Fill	100	CY	$	13.83	$	1,383		
6.3	Embankment Compaction	100	CY	$	2.50	$	250		
6.4	Side Slope Revegetation Seeding and Mulching	0	AC	$	3,600.00	$	36		
6.5	Side Slope Revegetation Topsoil Type B	30	CY	$	5.00	$	150		
6.6	Signage Setup/Tear Down/Maintenance	1	LS	$	10,000.00	$	10,000		
6.7	Flagging - 2-person crew	20	DAY	$	576.00	$	11,520		
6.8	Gravel Borrow incl Haul (9" thickness)	30	TON	$	14.00	$	420	$	29,000
7.0	SR-104 Stellas/Marsh Flood Protection Barrier								
7.1	Sheet Pile Wall - Furnishing and Driving Steel Pile	550.0	LF	$	115.00	$	63,250		
7.3	Sheet Pile Wall - Concrete Cap Installed	41	CY	$	120.00	$	4,920		
7.4	Signage Setup/Tear Down/Maintenance	1	LS	$	2,000.00	$	2,000		
7.5	Flagging - 2-person crew	5	DAY	$	576.00	$	2,880	$	74,000
8.0	Miscellaneous								
8.1	Parking Area Fill (Salvaged from Daylight Channel and Wetland Berm)	10,800.0	CY	$	10.00	$	108,000	$	108,000
					Equipment, Labor, and Material Costs	$	7,224,620	$	7,227,000
					Escalation Adjustement (10.0%)	$	722,462		
					Taxes (10.3%)	$	744,136		
					Bonding & Insurance (5%)	$	361,231		
					Contingency (25%)	$	1,806,155		
					Construction Cost	$	10,858,604	$	10,859,000
					Real Estate Agreements, Easements, Real Property (TBD)	$	-		
					Engineering, Permits (15% of Construction)	$	1,628,791		
					Construction Administration (10% of Construction)	$	1,085,860		
					Project Costs	$	13,573,255	$	13,574,000

Notes:

[1] Costs are rounded to nearest thousand.

% = percent

AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

Liner and contaminated sediment depth inside existing treatment pond assumed to total 1 ft.

TABLE 3B
ALTERNATIVE 6B
DAYLIGHT WITH FLOODWALL
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	$ 50,000
2.0	Marina Beach Park (Channel and Habitat Features)					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	12,200	CY	$ 10.00	$ 122,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	6,100	CY	$ 10.00	$ 61,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	6,100	CY	$ 95.35	$ 581,635	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 81,500	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 1,147,000
3.0	Daylight Channel Construction					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	21,100	CY	$ 7.00	$ 147,700	
3.5.1	Excavated Material (uncontaminated) for use in Parking Area Fill	10,600	CY	$ -	$ -	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	10,600	CY	$ 95.35	$ 1,010,710	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	107,700	SF	$ 2.50	$ 269,250	
3.8	Self-regulating Tidegate	1	LS	$ 400,000.00	$ 400,000	
3.9	Import Clean Liner Backfill	10,000	CY	$ 16.20	$ 162,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 37,500	
3.2	Side Slope Revegetation Topsoil Type B	2,500	CY	$ 5.00	$ 12,500	
3.2	Side Slope Revegetation Seeding and Mulching	2	AC	$ 3,600.00	$ 5,616	
3.2	Bench Plug Planting (Sedges, Hairgrass, Blurus)	20,000	EA	$ 2.00	$ 40,000	
3.2	Large Woody Debris	200	EA	$ 1,000.00	$ 200,000	$ 3,541,000
4.0	Marsh Improvements					
4.1	Clearing and Grubbing (remove cattails)	1	AC	$ 10,000.00	$ 13,659	
4.2	Channel Excavation/Dredging	9,028	CY	$ 50.00	$ 451,400	
4.3	Haul and Dispose Excavated Material (uncontaminated)	2,853	CY	$ 10.00	$ 28,530	
4.4	Haul and Dispose Excavated Material (contaminated)	6,175	CY	$ 95.35	$ 588,786	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Demo and Dispose of Pond Pump Station	1	LS	$ 50,000.00	$ 50,000	
4.7	Decomission wells	5	EA	$ 5,000.00	$ 25,000	
4.8	Revegetation	1	LS	$ 50,000.00	$ 50,000.00	$ 1,233,000
5.0	Railroad Levee and Sheet Pile Floodwall					
5.1	BNSF Railroad ROW Work					
5.1.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
5.1.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
5.1.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
5.2	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
5.3	Backfill Soil	9,500	CY	$ 13.83	$ 131,385	
5.5	Side Slope Revegetation Seeding and Mulching	1	AC	$ 3,600.00	$ 3,600	
5.6	Side Slope Revegetation Topsoil Type B	1,600	CY	$ 5.00	$ 8,000.00	
5.9	Sheet Pile Wall - Furnishing and Driving Steel Pile	43,400	SF	$ 50.00	$ 2,170,000.00	
6.0	Sheet Pile Wall - Concrete Cap Installed	161.0	CY	$ 120.00	$ 19,320	$ 2,593,000
6.0	Harbor Square / SR-104 Flood Wall					
6.1	Temporary Erosion Control and Sediment Control	1	LS	$ 5,000.00	$ 5,000	
6.2	Sheet Pile Wall - Furnishing and Driving Steel Pile	700	SF	$ 50.00	$ 35,000	

TABLE 3B
ALTERNATIVE 6B
DAYLIGHT WITH FLOODWALL
COST ESTIMATE

6.6	Signage Setup/Tear Down/Maintenance	1.0	LS	$	2,000.00	$	2,000	
6.7	Flagging - 2-person crew	5	DAY	$	576.00	$	2,880	
6.8	Sheet Pile Wall - Concrete Cap Installed	6	CY	$	120.00	$	720	$ 46,000
7.0	SR-104 Stellas/Marsh Flood Protection Barrier							
7.1	Sheet Pile Wall - Furnishing and Driving Steel Pile	2,750	SF	$	50.00	$	137,500	
7.3	Sheet Pile Wall - Concrete Cap Installed	41	CY	$	120.00	$	4,920	
7.4	Signage Setup/Tear Down/Maintenance	1	LS	$	2,000.00	$	2,000	
7.5	Flagging - 2-person crew	5	DAY	$	576.00	$	2,880.00	$ 148,000
8.0	Miscellaneous							
8.1	Parking Area Fill (Salvaged from Daylight Channel and Wetland Berm)	10,800	CY	$	10.00	$	108,000	$ 108,000
Equipment, Labor, and Material Costs						$	8,861,992	$ 8,866,000
Escalation Adjustement (10.0%)						$	886,199	
Taxes (10.3%)						$	912,785	
Bonding & Insurance (5%)						$	443,100	
Contingency (25%)						$	2,215,498	
					Construction Cost	$	13,319,573	$ 13,320,000
					Real Estate Agreements, Easements, Real Property (TBD)	$	-	
					Engineering, Permits (15% of Construction)	$	1,997,936	
					Construction Administration (10% of Construction)	$	1,331,957	
					Project Costs	$	16,649,467	$ 16,650,000

Notes:

[1] Costs are rounded to nearest thousand.

% = percent

AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

Liner and contaminated sediment depth inside existing treatment pond assumed to total 1 ft.

TABLE 4
ALTERNATIVE 7
DAYLIGHT WITH TIDEGATE FLOOD BERMS AT SR-104
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	$ 50,000
2.0	Marina Beach Park (Channel and Habitat Features)					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	12,200	CY	$ 10.00	$ 122,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	6,100	CY	$ 10.00	$ 61,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	6,100	CY	$ 95.35	$ 582,000	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 82,000	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	$ 1,147,000
3.0	Daylight Channel Construction					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	19,900	CY	$ 7.00	$ 139,000	
3.5.1	Excavated Material (uncontaminated) for use in Parking Area & UNOCAL Fill	9,300	CY	$ -	$ -	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	10,600	CY	$ 95.35	$ 1,011,000	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	107,700	SF	$ 2.50	$ 269,000	
3.8	Self-regulating Tidegate	1	LS	$ 400,000.00	$ 400,000	
3.9	Import Clean Liner Backfill	10,000	CY	$ 16.20	$ 162,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 38,000	
3.2	Side Slope Revegetation Topsoil Type B	2,600	CY	$ 5.00	$ 13,000	
3.2	Side Slope Revegetation Seeding and Mulching	2	AC	$ 3,600.00	$ 5,868	
3.2	Bench Plug Planting (Sedges, Hairgrass, Blurus)	20,000	EA	$ 2.00	$ 40,000	
3.2	Large Woody Debris	200	EA	$ 1,000.00	$ 200,000	$ 3,533,000
4.0	Marsh Improvements					
4.1	Clearing and Grubbing (remove cattails)	1	AC	$ 10,000.00	$ 14,000	
4.2	Channel Excavation/Dredging	9,028	CY	$ 50.00	$ 451,000	
4.3	Haul and Dispose Excavated Material (uncontaminated)	2,853	CY	$ 10.00	$ 29,000	
4.4	Haul and Dispose Excavated Material (contaminated)	6,175	CY	$ 95.35	$ 589,000	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Demo and Dispose of Pond Pump Station	1	LS	$ 50,000.00	$ 50,000	
4.7	Decomission wells	5	EA	$ 5,000.00	$ 25,000	
4.8	Revegetation	1	LS	$ 50,000.00	$ 50,000.00	$ 1,233,000
5.0	Tide Gate and Flood Wall					
5.1	BNSF Railroad ROW Work					
5.1.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
5.1.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
5.1.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
5.1.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
5.1.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
5.2	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
5.3	Tide Gates	2	LS	$ 100,000.00	$ 200,000.00	
5.4	Tide Gate Walkway	1	LS	$ 50,000.00	$ 50,000.00	
5.5	Sheet Pile Wall - Furnishing and Driving Steel Pile	120	LF	$ 115.00	$ 13,800.00	
5.6	Sheet Pile Wall - Concrete Cap Installed	240	CY	$ 120.00	$ 28,800	
5.7	Tide Gate Headwall	1	LS	$ 100,000.00	$ 100,000.00	$ 698,000
8.0	Miscellaneous					
8.1	UNOCAL Area Fill (Salvaged from Daylight Channel)	150.0	CY	$ 10.00	$ 1,500	
8.2	Parking Area Fill (Salvaged from Daylight Channel)	9,100	CY	$ 10.00	$ 91,000.00	$ 93,000

TABLE 4
ALTERNATIVE 7
DAYLIGHT WITH TIDEGATE FLOOD BERMS AT SR-104
COST ESTIMATE

Equipment, Labor, and Material Costs	$	6,753,000	$	6,754,000
Escalation Adjustement (10.0%)	$	675,300		
Taxes (10.3%)	$	695,559		
Bonding & Insurance (5%)	$	337,650		
Contingency (25%)	$	1,688,250		
Construction Cost	$	10,149,759.00	$	10,150,000
Real Estate Agreements, Easements, Real Property (TBD)	$	-		
Engineering, Permits (15% of Construction)	$	1,522,464		
Construction Administration (10% of Construction)	$	1,014,976		
Project Costs	$	12,687,199	$	12,688,000

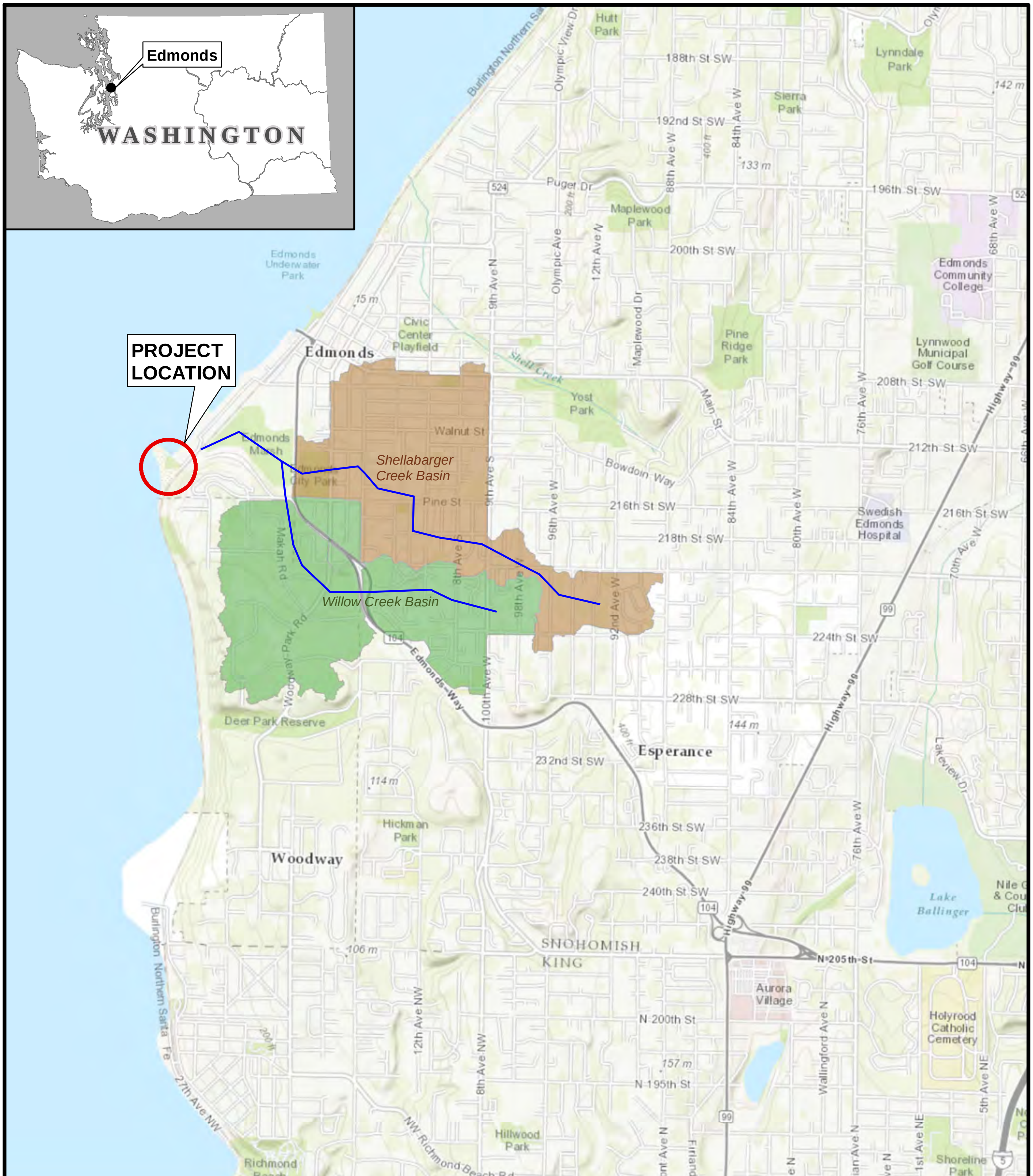
Notes:

[1] Costs are rounded to nearest thousand.

% = percent

AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

Liner and contaminated sediment depth inside existing treatment pond assumed to total 1 ft.



0 ½ 1

Scale in Miles

N
W E
S

Willow Creek Daylight Project
Expanded Marsh Concept Design and Hydraulic Modeling
Edmonds, Washington

VICINITY MAP

March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

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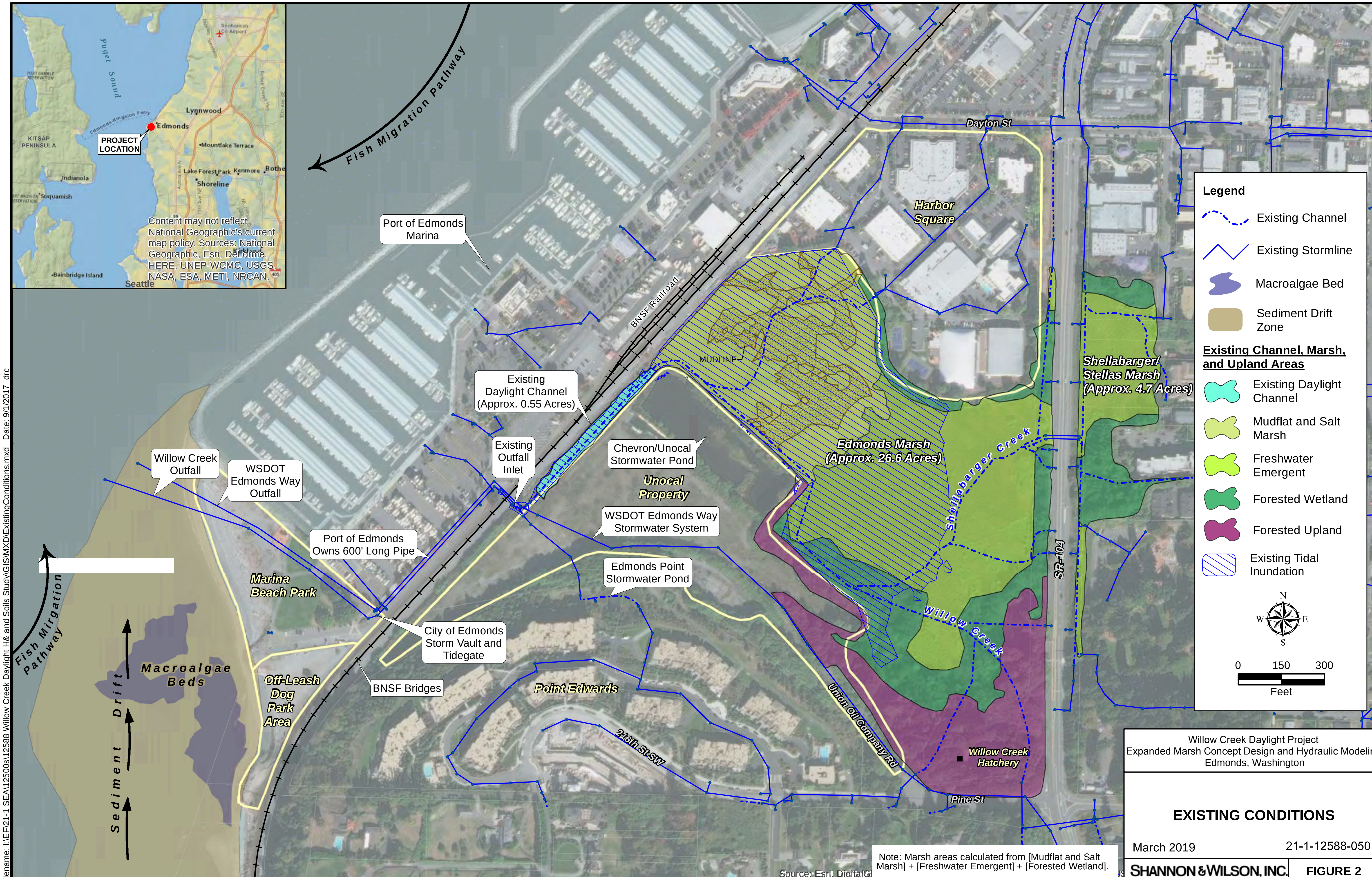

Willow Creek Daylight Project
Expanded Marsh Concept Design and Hydraulic Modeling
Edmonds, Washington

EXISTING CONDITIONS

March 2019 | 21-1-12588-050

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FIGURE 2

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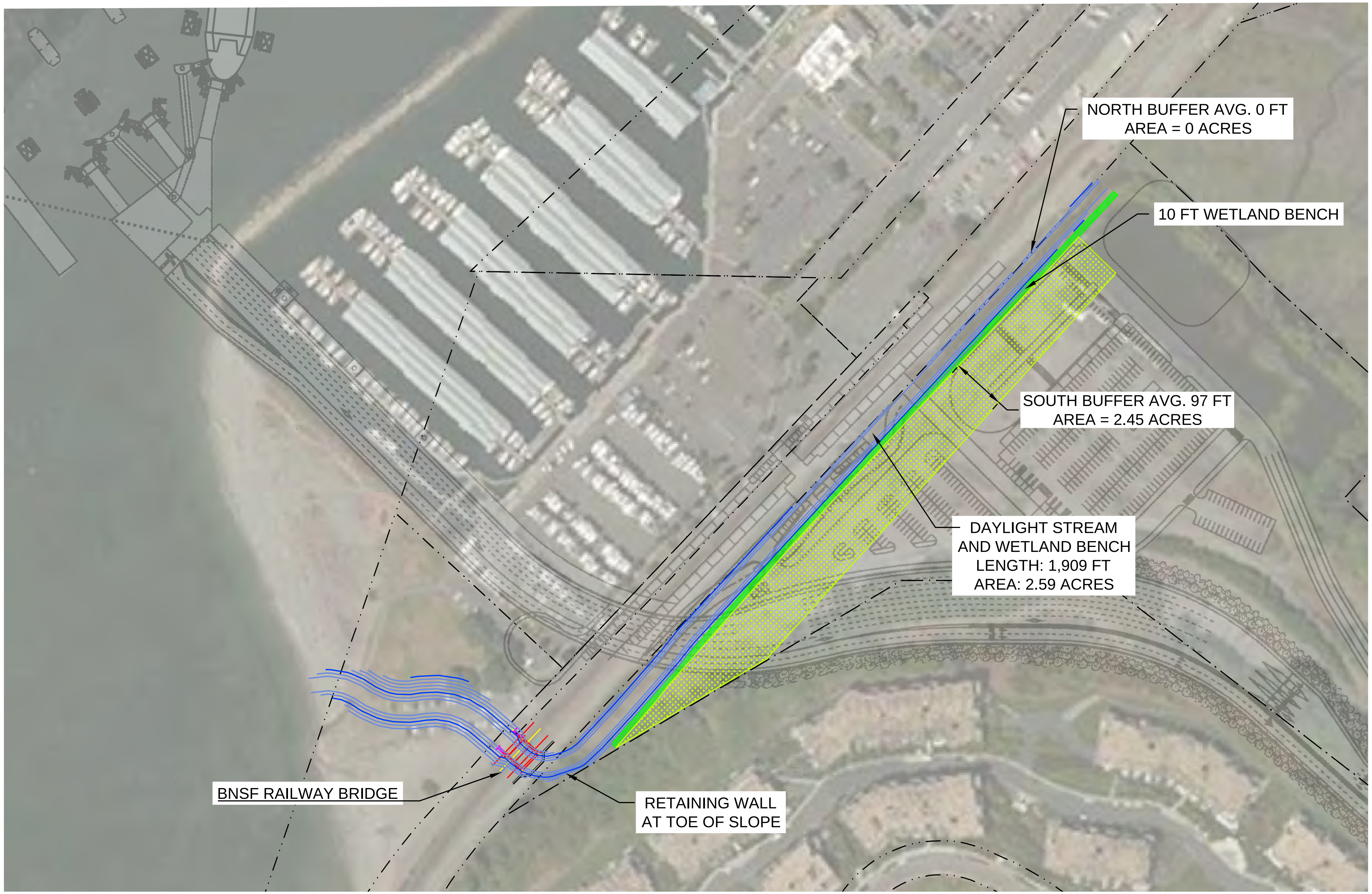

LEGEND

PROPOSED DAYLIGHT CONTOUR

WETLAND RESTORATION

RIPARIAN BUFFER

SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet
Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 1
ALIGNMENT AND BUFFERS

March 2019 21-1-12588-050

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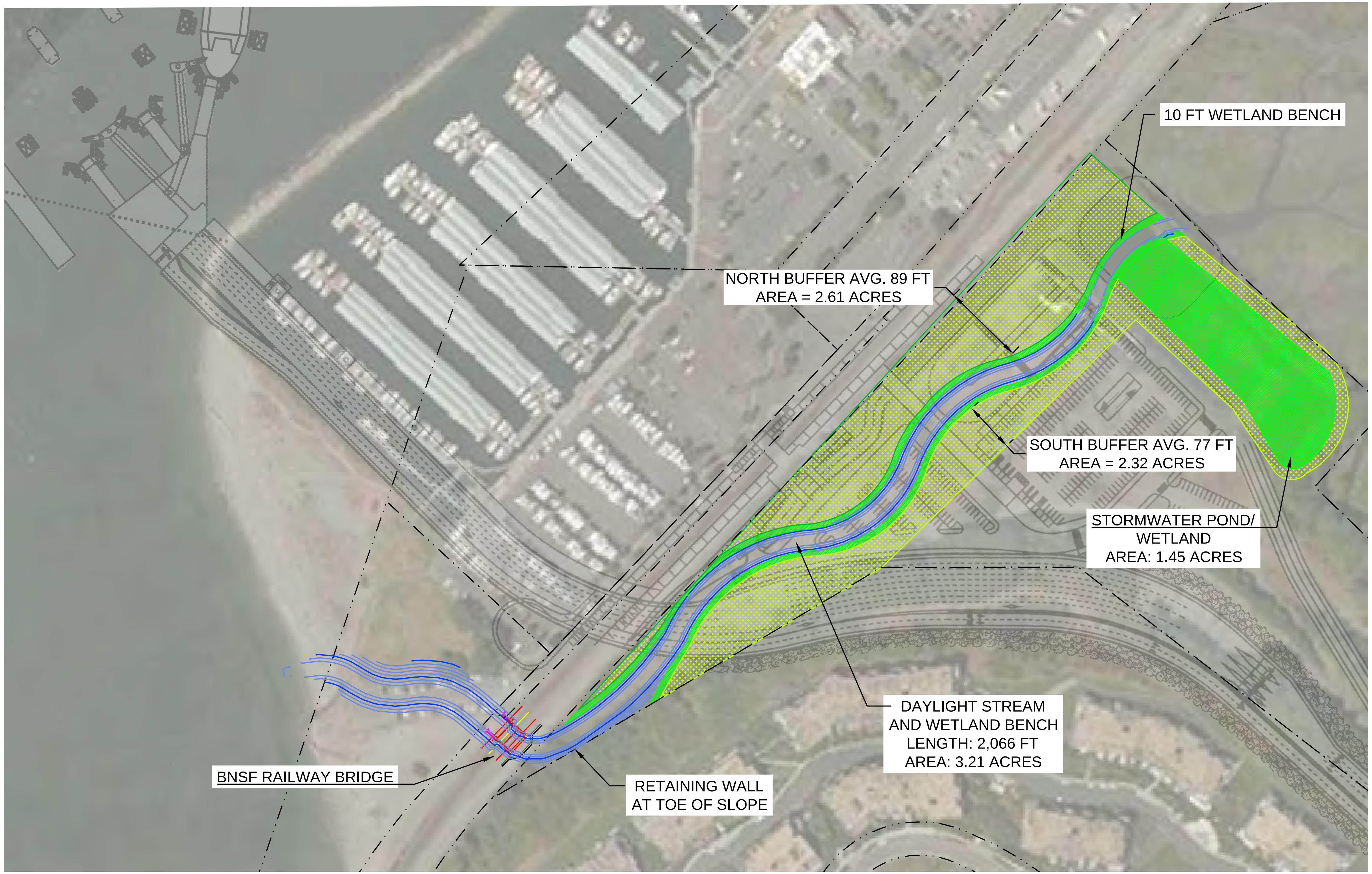
FIG. 3

Filename: \\SEA-FS1\Vol1\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\211-12588 Buffer Options - 2018.dwg Date: 03-08-2019 Login: CCB



N

LEGEND

- PROPOSED DAYLIGHT CONTOUR
- WETLAND RESTORATION
- RIPARIAN BUFFER
- SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet
Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 2
ALIGNMENT AND BUFFERS

March 2019 21-1-12588-050

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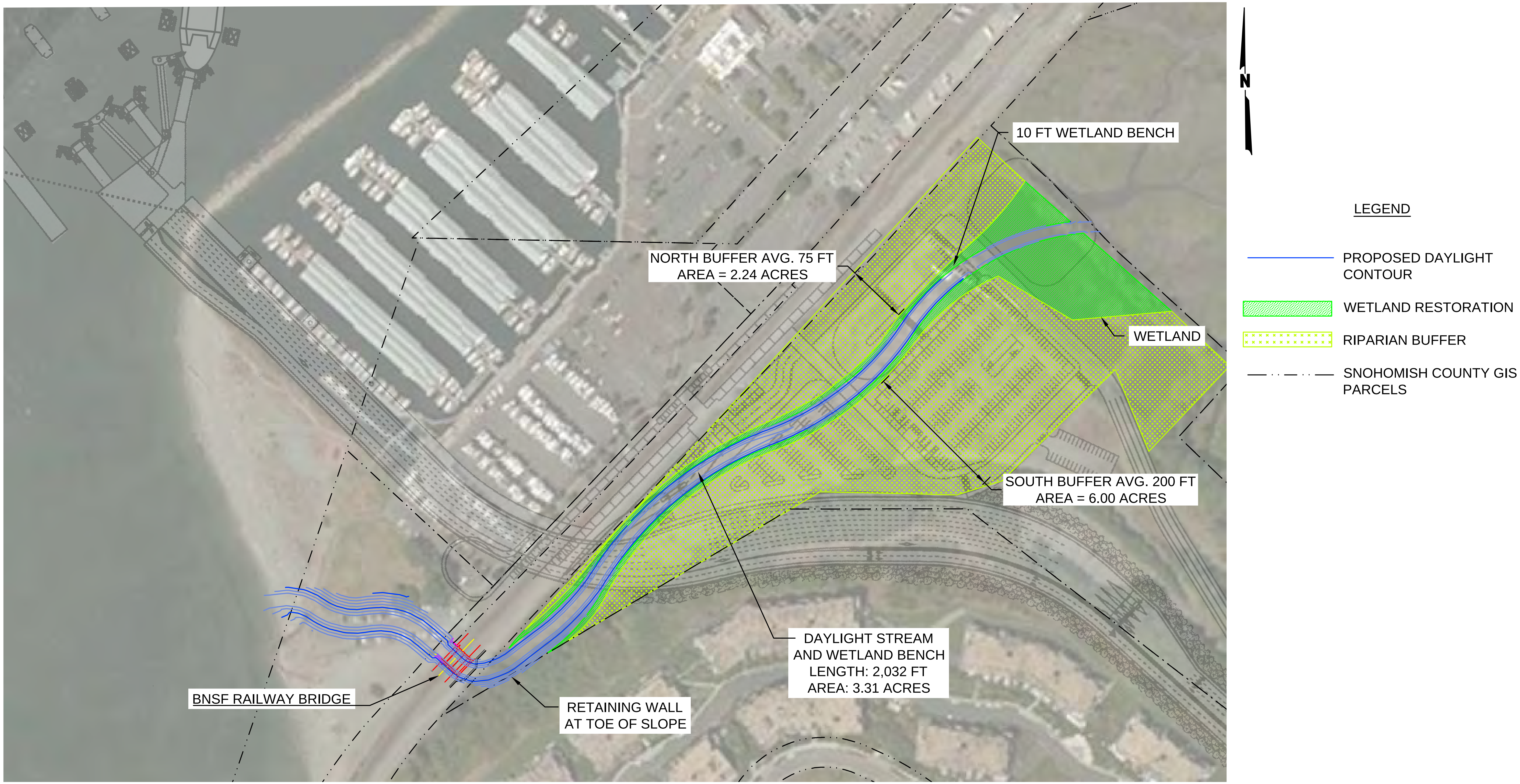
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-12588 Buffer Options - 2018.dwg Date: 03-09-2019 Login: CCB



NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet
Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 3
ALIGNMENT AND BUFFERS

March 2019 21-1-12588-050

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FIG. 5

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 4
ALIGNMENT AND BUFFERS

March 2019 | 21-1-12588-050

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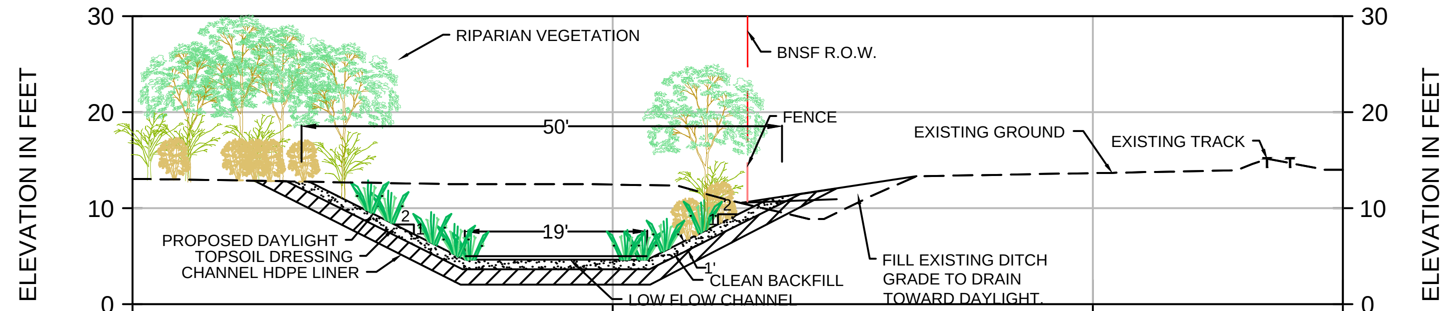
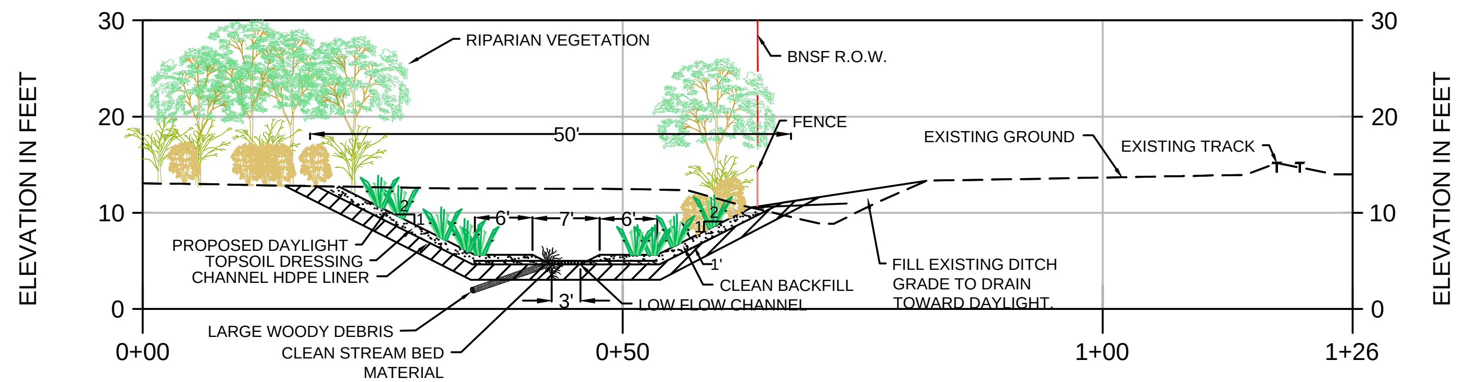
FIG. 6

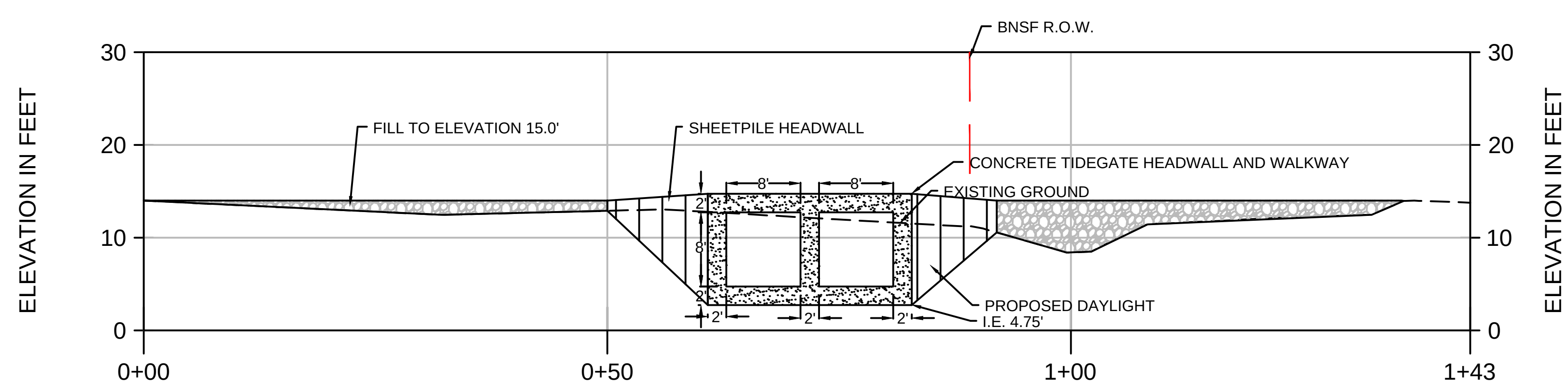
Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-12588 Buffer Options - 2018.dwg Date: 03-09-2019 Login: CCB



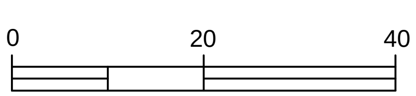
TYPICAL DAYLIGHT CHANNEL SECTION - WITHOUT HABITAT BENCHES



TYPICAL DAYLIGHT CHANNEL SECTION - WITH HABITAT
BENCHES AND LARGE WOODY DERIS



TIDEGATE SECTION - (2) 8 'X 8' TIDEGATES



Scale in Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

TYPICAL SECTIONS

March 2019 | 21-1-12588-050

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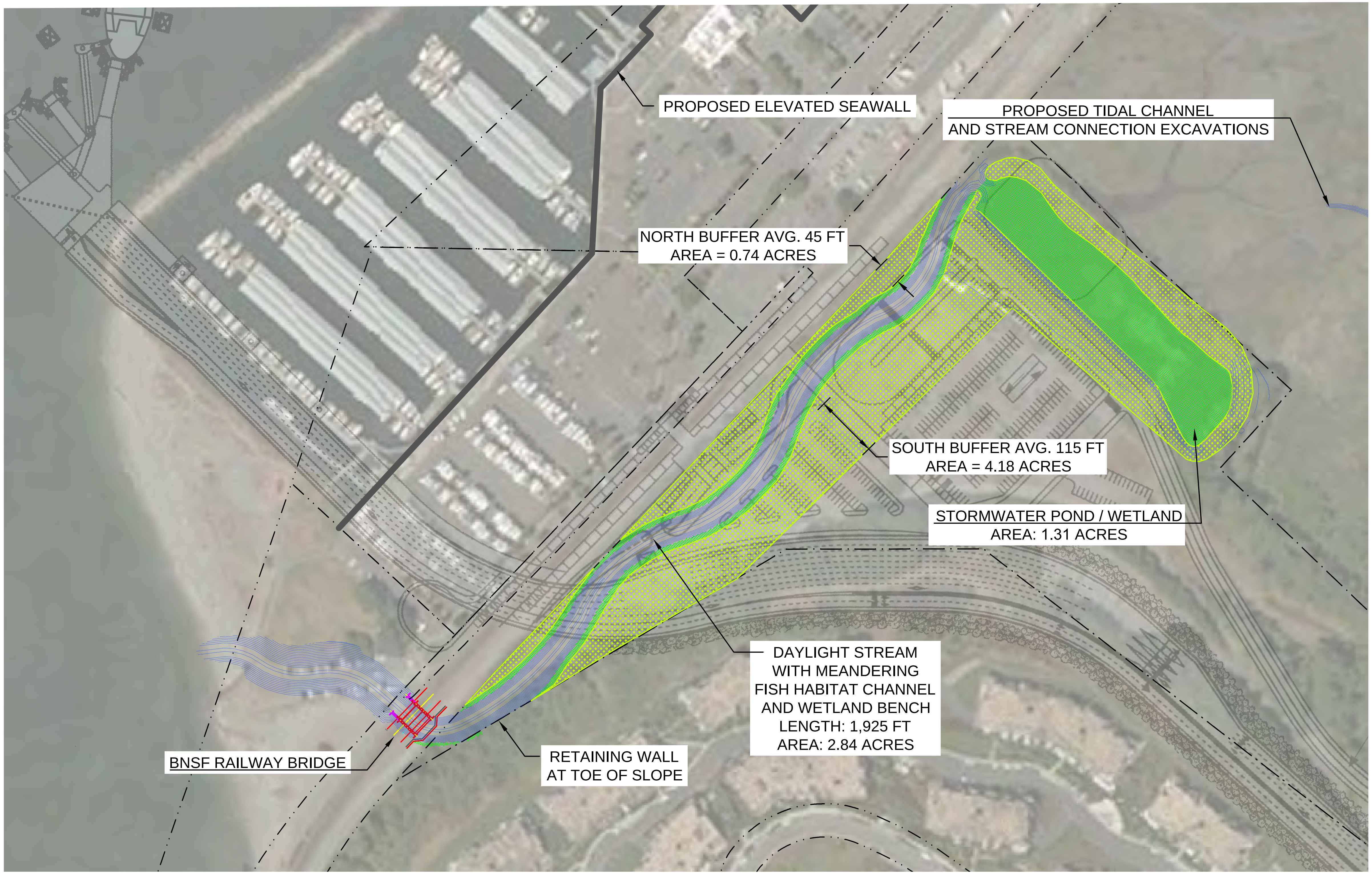
FIG. 7

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-1-12588-050_Fig 1_Typical Sections_09MAR2019.dwg Date: 03-09-2019 Login: CCB



N

LEGEND

- PROPOSED FLOOD PROTECTION STRUCTURE
- PROPOSED DAYLIGHT CONTOUR
- WETLAND RESTORATION
- RIPARIAN BUFFER
- SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 5 ALIGNMENT

March 2019 21-1-12588-050

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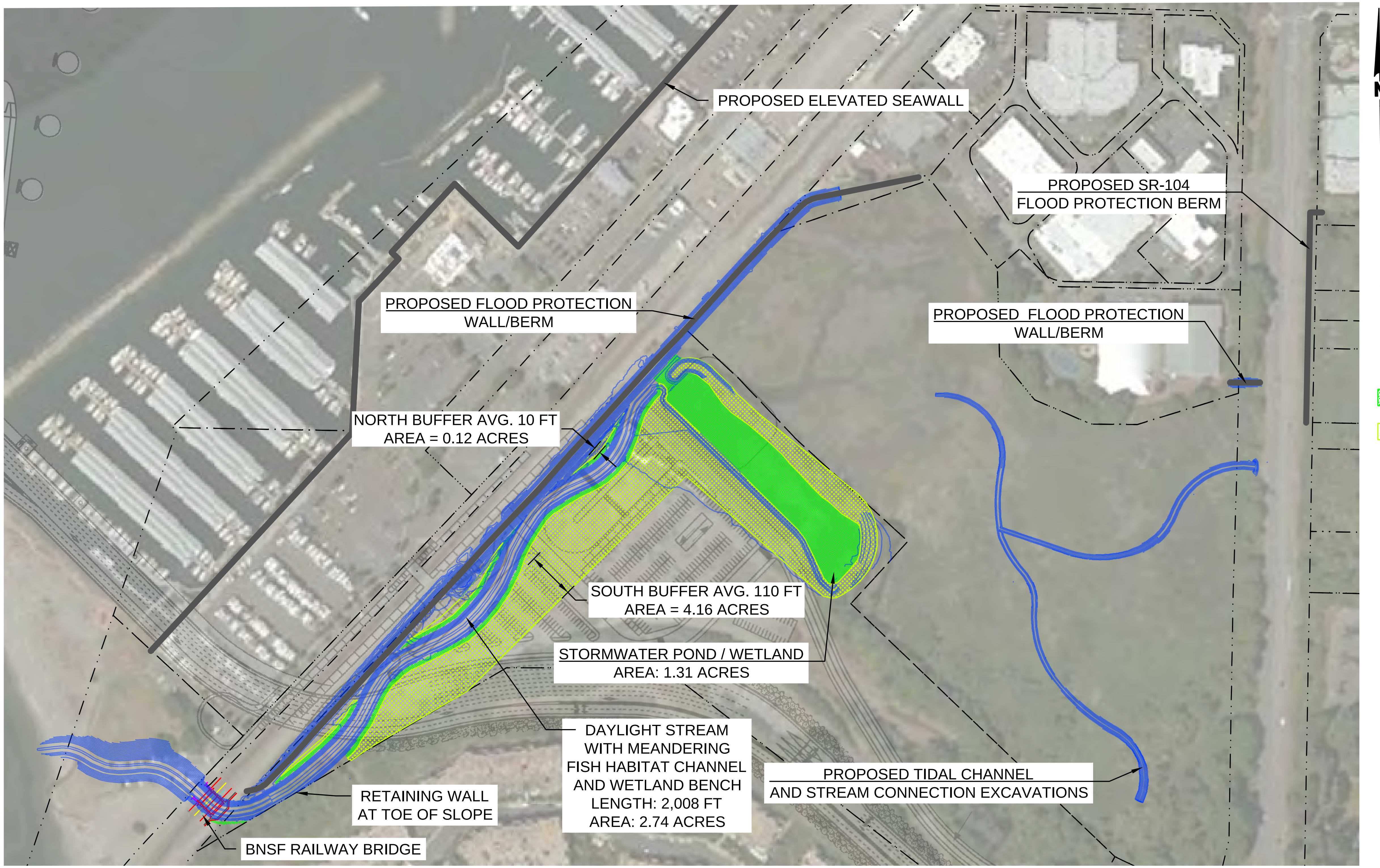
FIG. 8

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\GradingFigures_28FEB2018\CADD\211-12588 Buffer Options - 2018 - Copy.dwg Date: 03-09-2019 Login: CCB



LEGEND

- PROPOSED FLOOD PROTECTION STRUCTURE
- PROPOSED DAYLIGHT CONTOUR
- WETLAND RESTORATION
- RIPARIAN BUFFER
- SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 250 500

Scale in Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 6 ALIGNMENT

March 2019 21-1-12588-050

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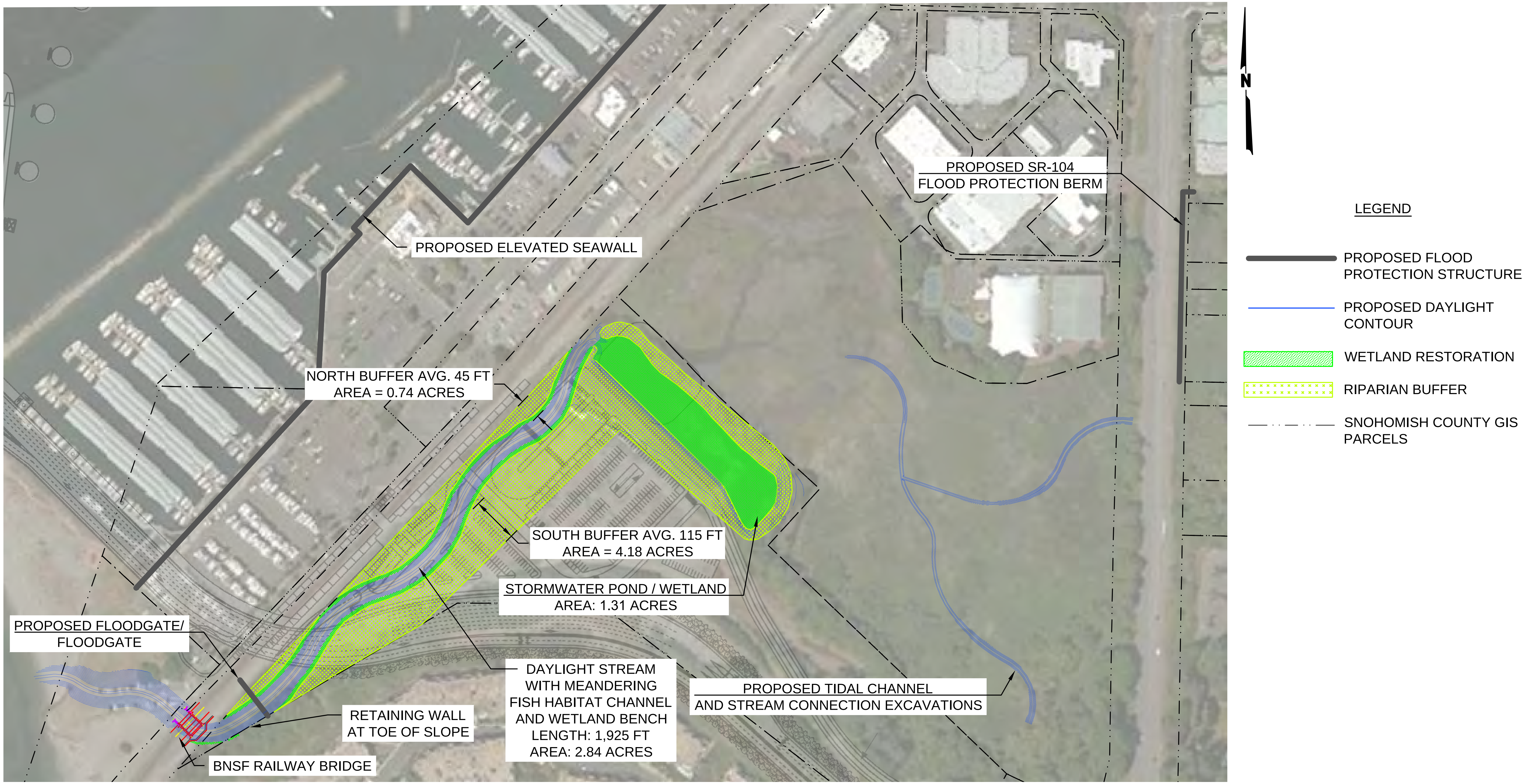
FIG. 9

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\GradingFigures_28FEB2018\CADD\211-12588 Buffer Options - 2018 - Copy.dwg Date: 03-09-2019 Login: CCB



NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 250 500

Scale in Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 7
ALIGNMENT

March 2019 | 21-1-12588-050

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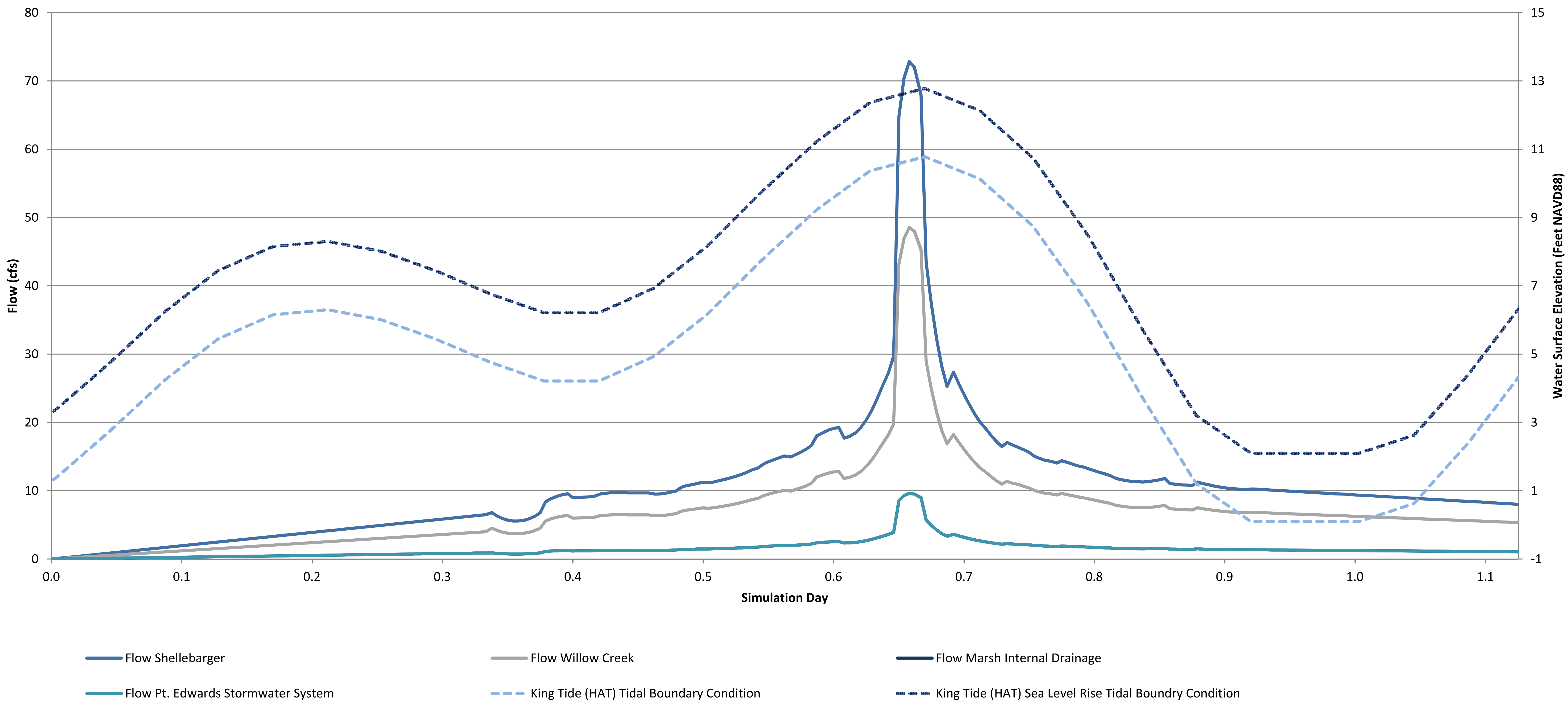
FIG. 10



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WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

1% (100-YR) AEP SAIC STREAM FLOOD HYDROGRAPHS AND KING TIDE/KING TIDE WITH SEA LEVEL RISE TIDAL BOUNDARY CONDITIONS

March 2019 | 21-1-12588-050

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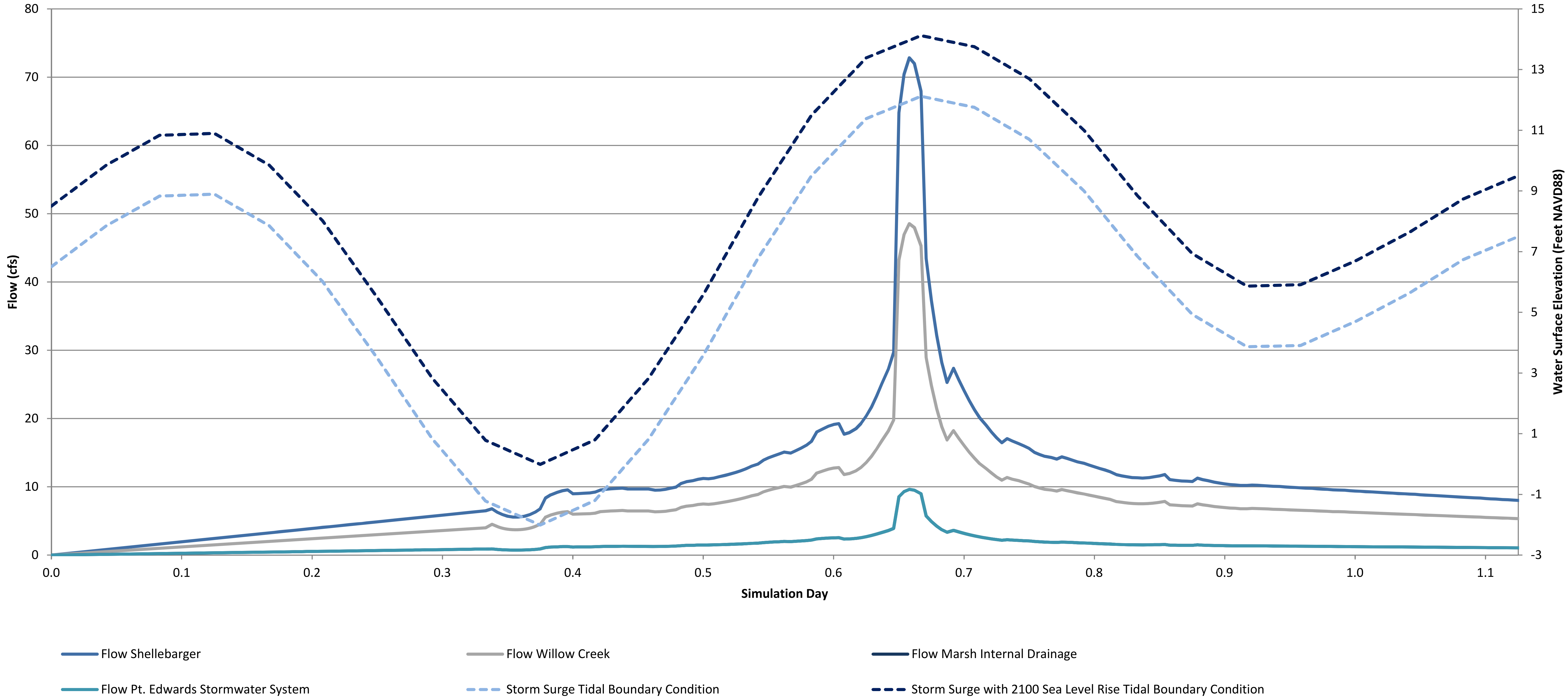
FIG. 11A



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

1% (100-YR) AEP SAIC STREAM FLOOD HYDROGRAPHS AND STORM SURGE/STORM SURGE WITH SEA LEVEL RISE TIDAL BOUNDARY CONDITIONS

March 2019 | 21-1-12588-050

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 11B

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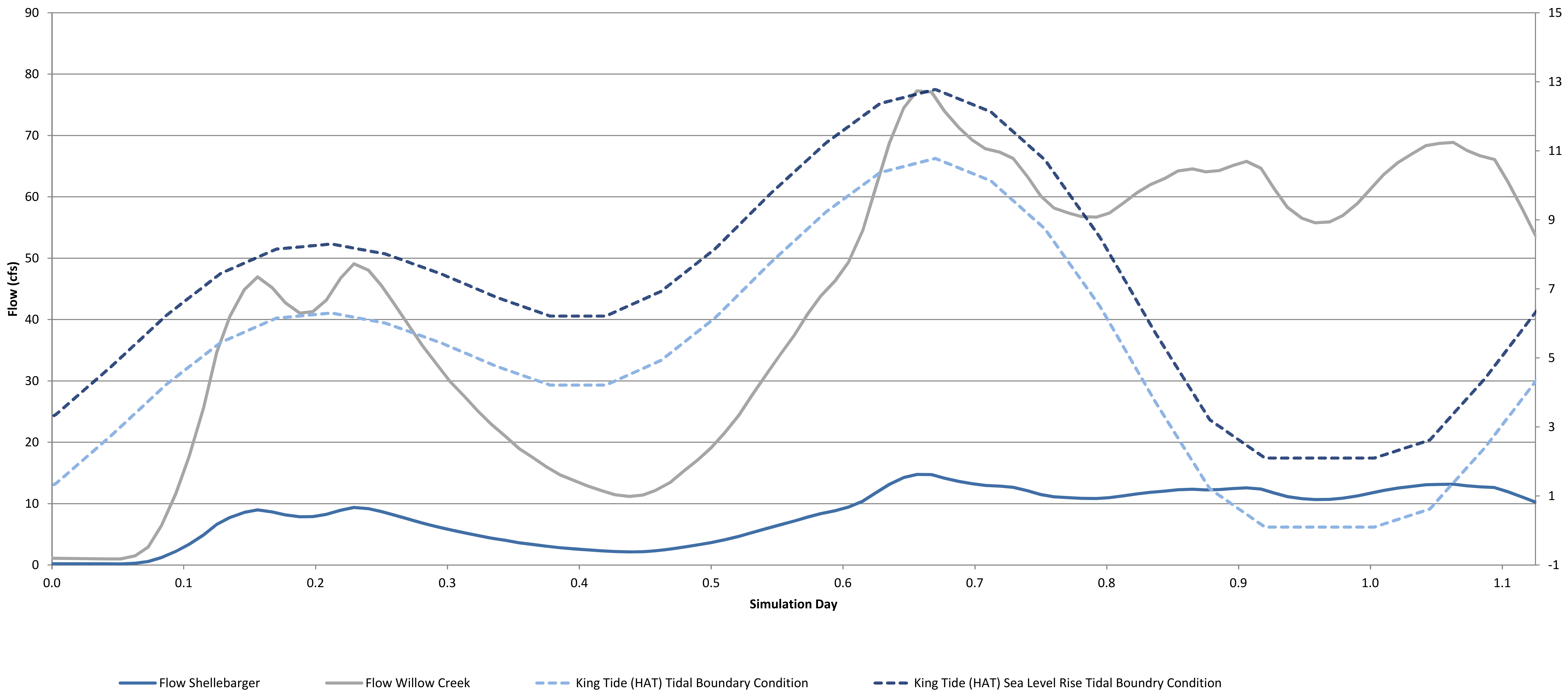

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

1% (100-YR) ANCHOR-QEA STREAM FLOOD HYDROGRAPHS AND KING TIDE/KING TIDE WITH SEA LEVEL RISE TIDAL BOUNDARY CONDITIONS

March 2019 21-1-12588-050

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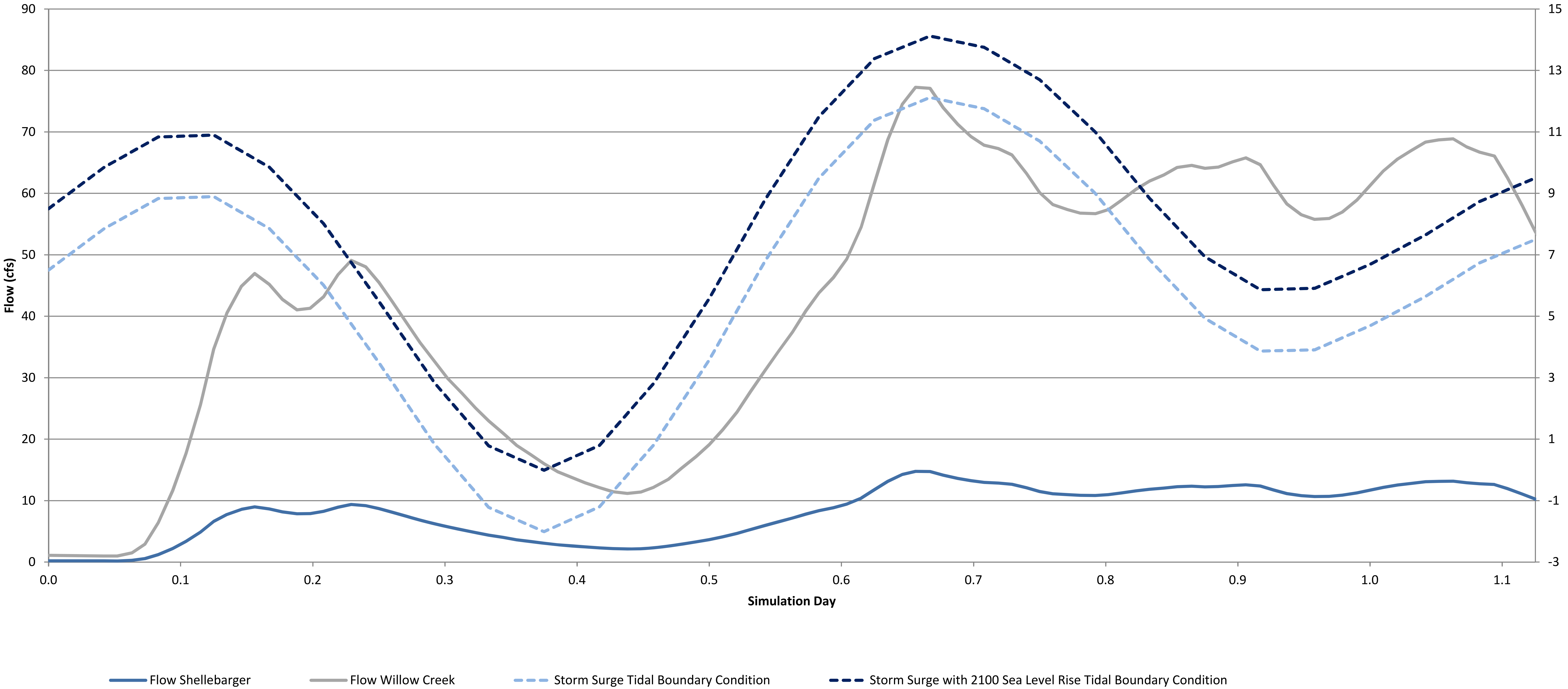
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 12A



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

1% (100-YR) ANCHOR-QEA STREAM FLOOD HYDROGRAPHS AND STORM SURGE TIDE/STORM SURGE WITH SEA LEVEL RISE TIDAL BOUNDARY CONDITIONS

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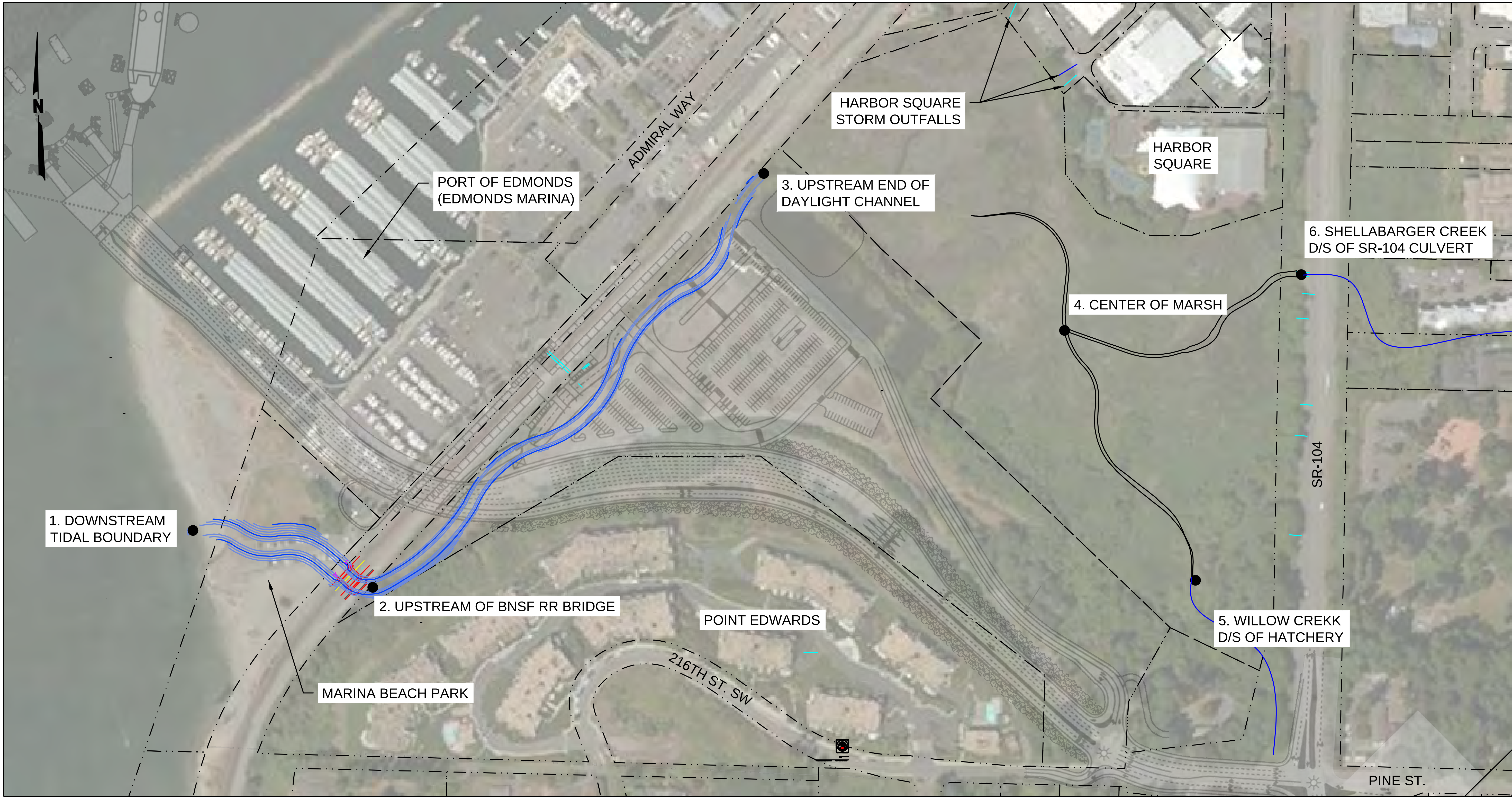
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 12B

Printed: 3-10-19 17:25 File: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Tables\[Figures.xlsx]Fig11B_Hydrographs-



LEGEND

PROPOSED DAYLIGHT CONTOUR

SNOHOMISH COUNTY GIS PARCELS

● MODELING NODE

0 250 500

Scale in Feet
Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

MODELING NODES

March 2019 21-1-12588-050

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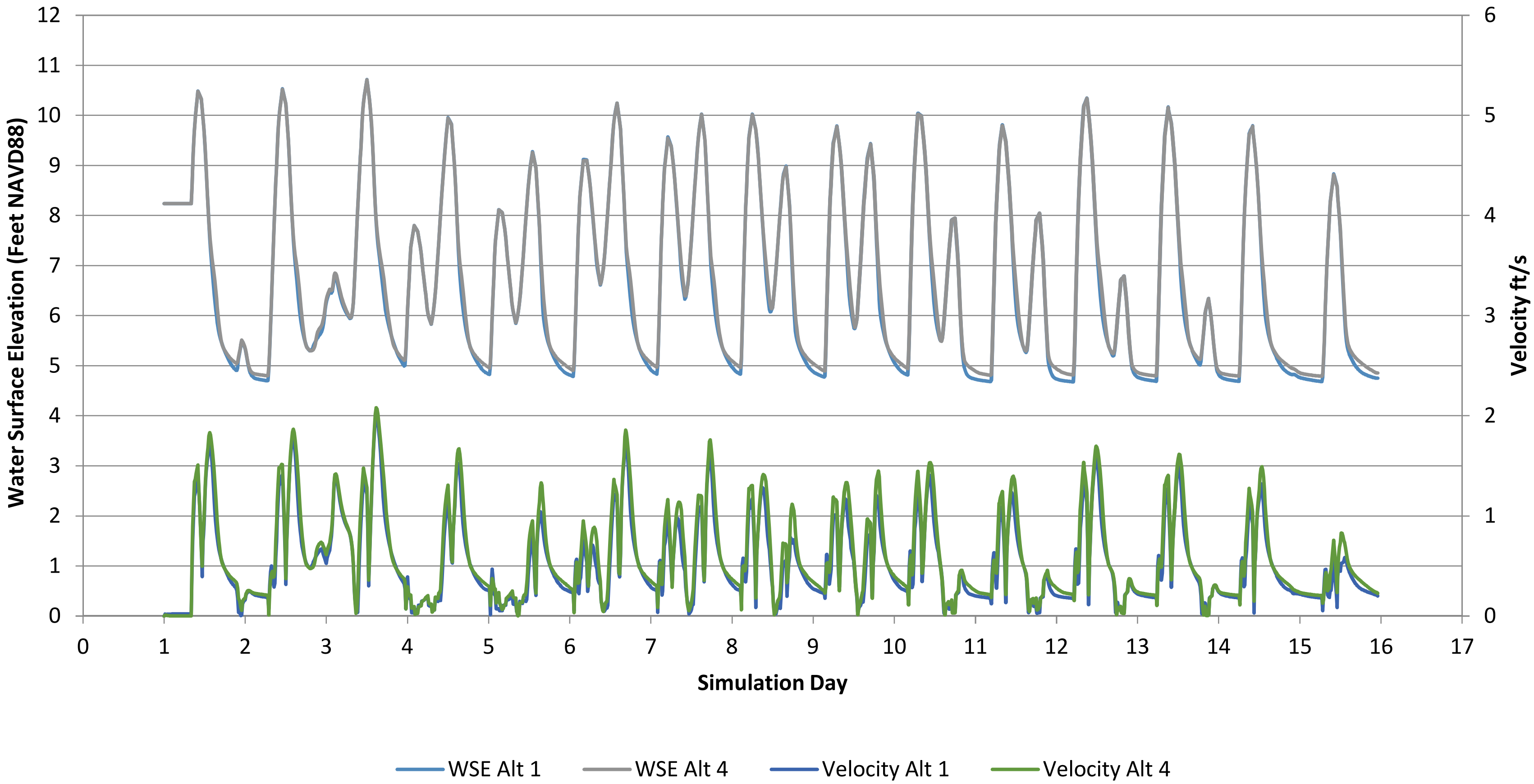
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 13



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 2 - Upstream of BNSF Bridge

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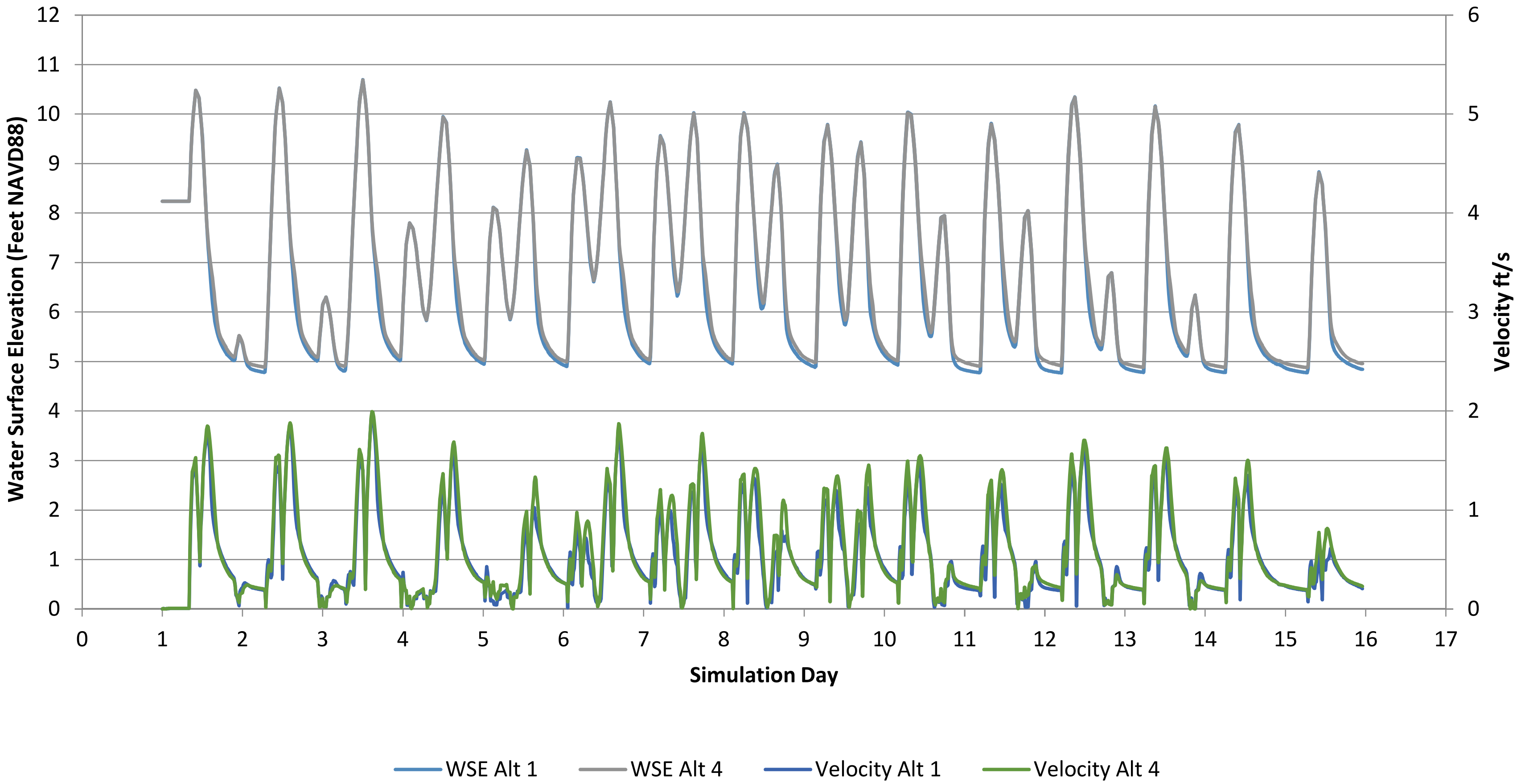
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 14

FIG. 14

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 2 100 Year>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Fish Habitat Water Surface Elevation and Velocity Node 2 - Upstream of BNSF Bridge

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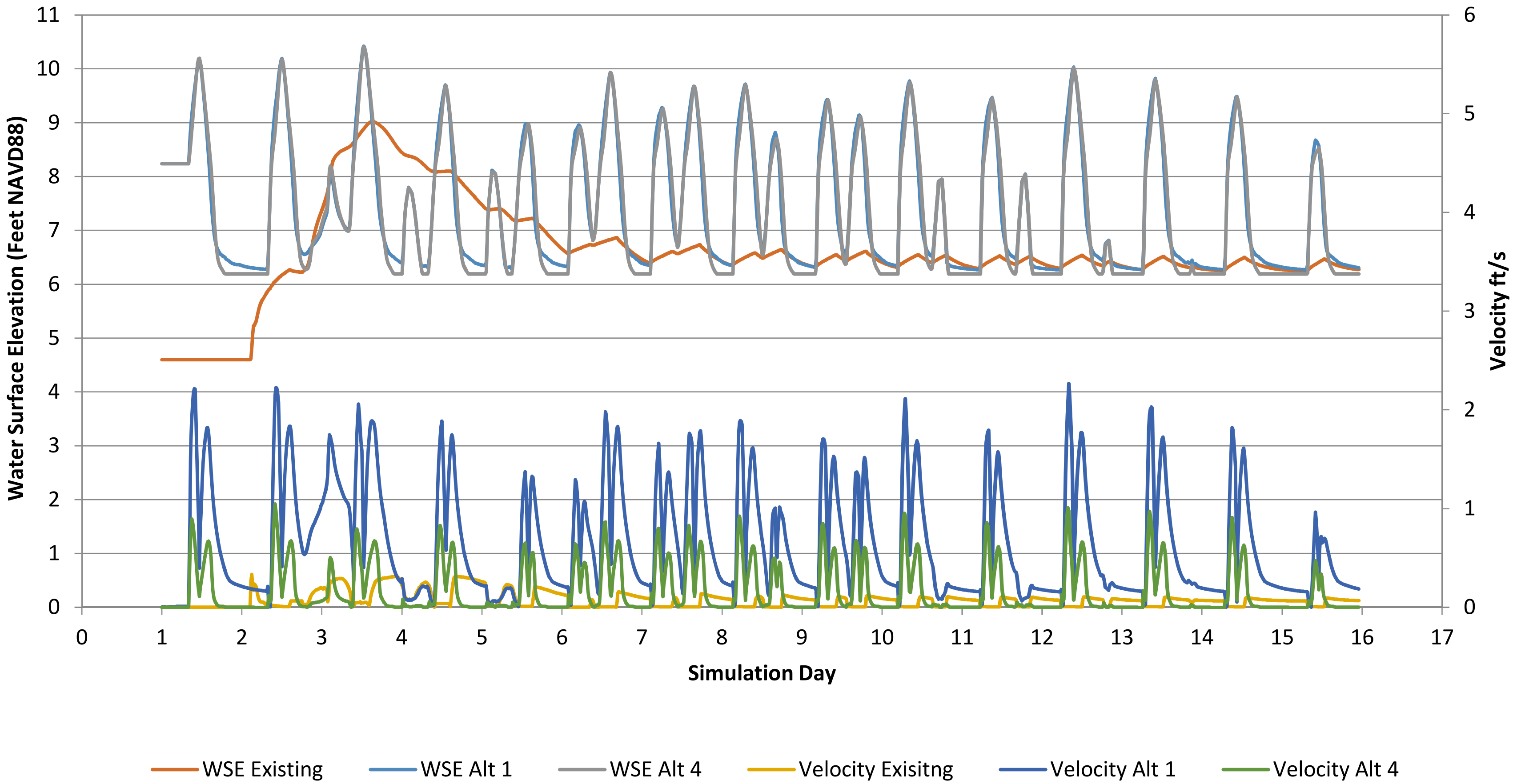
FIG. 15

FIG. 15



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 3 - Upstream of Daylight Channel

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FIG. 16

FIG. 16

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 3 100 Year >

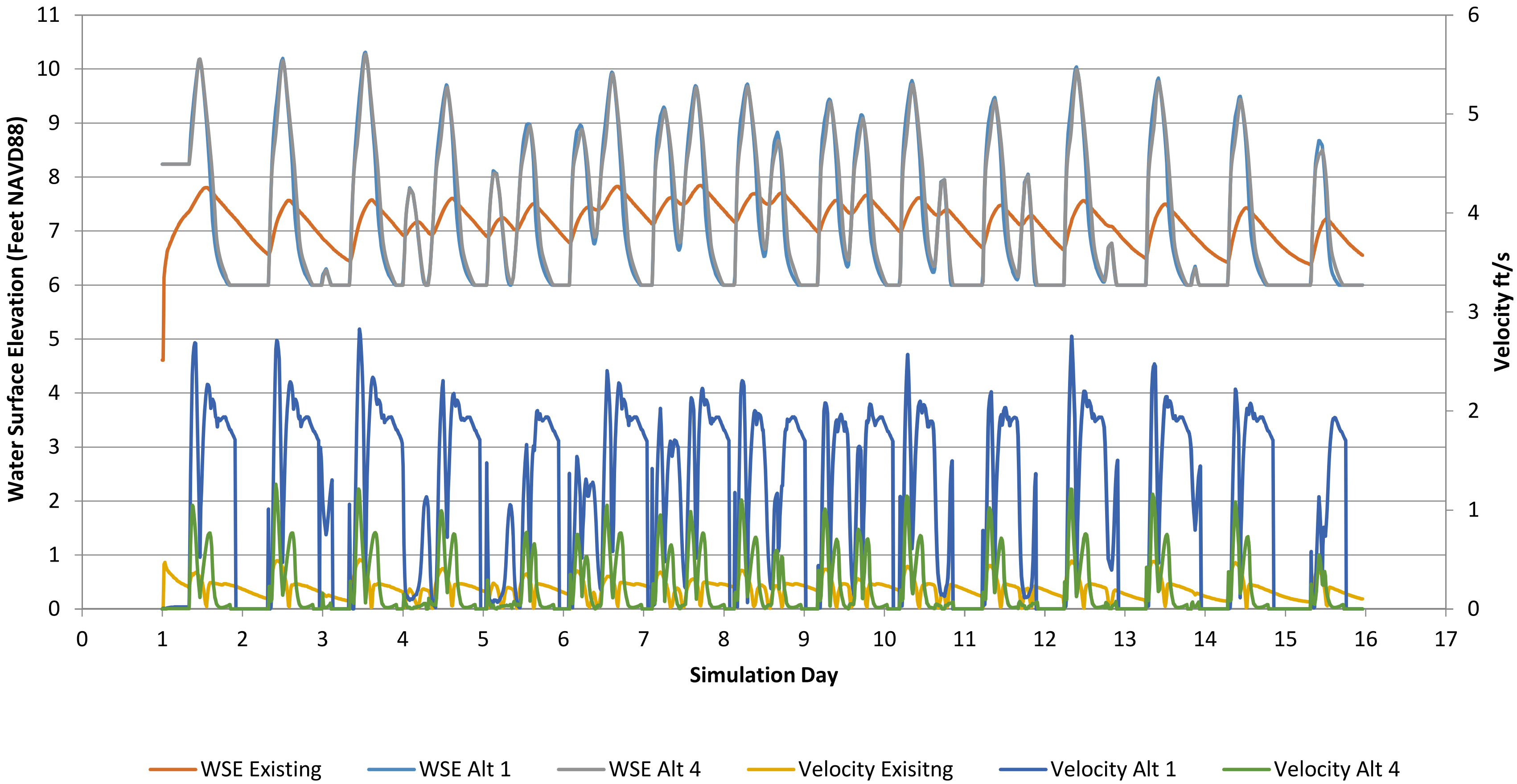

FIG. 17

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Habitat Water Surface Elevation and Velocity
Node 3 - Upstream of Daylight Channel

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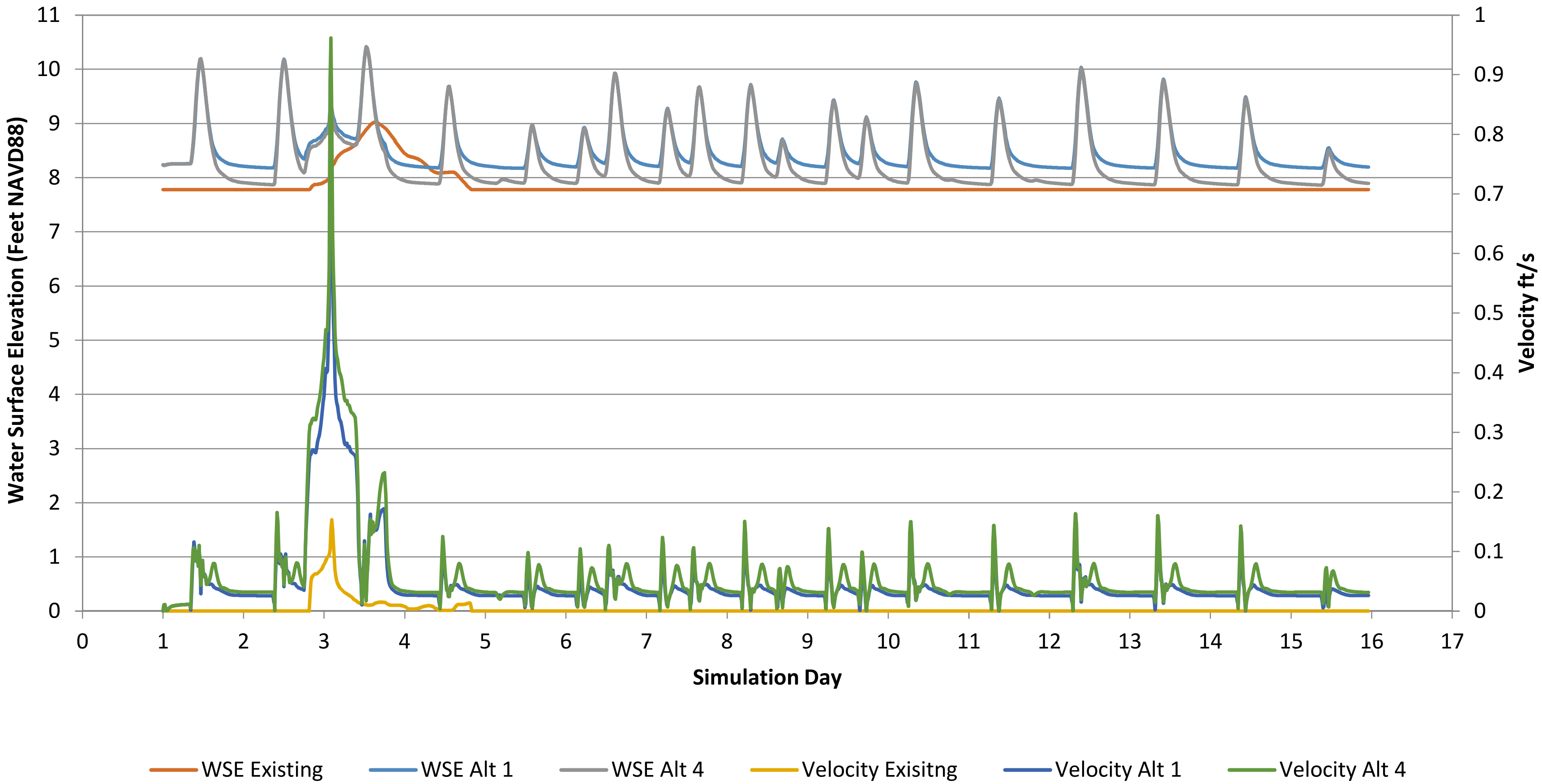
FIG. 17

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 3 Low Flow>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity Node 4 - Center of Marsh

March 2019 | 21-1-12588-050

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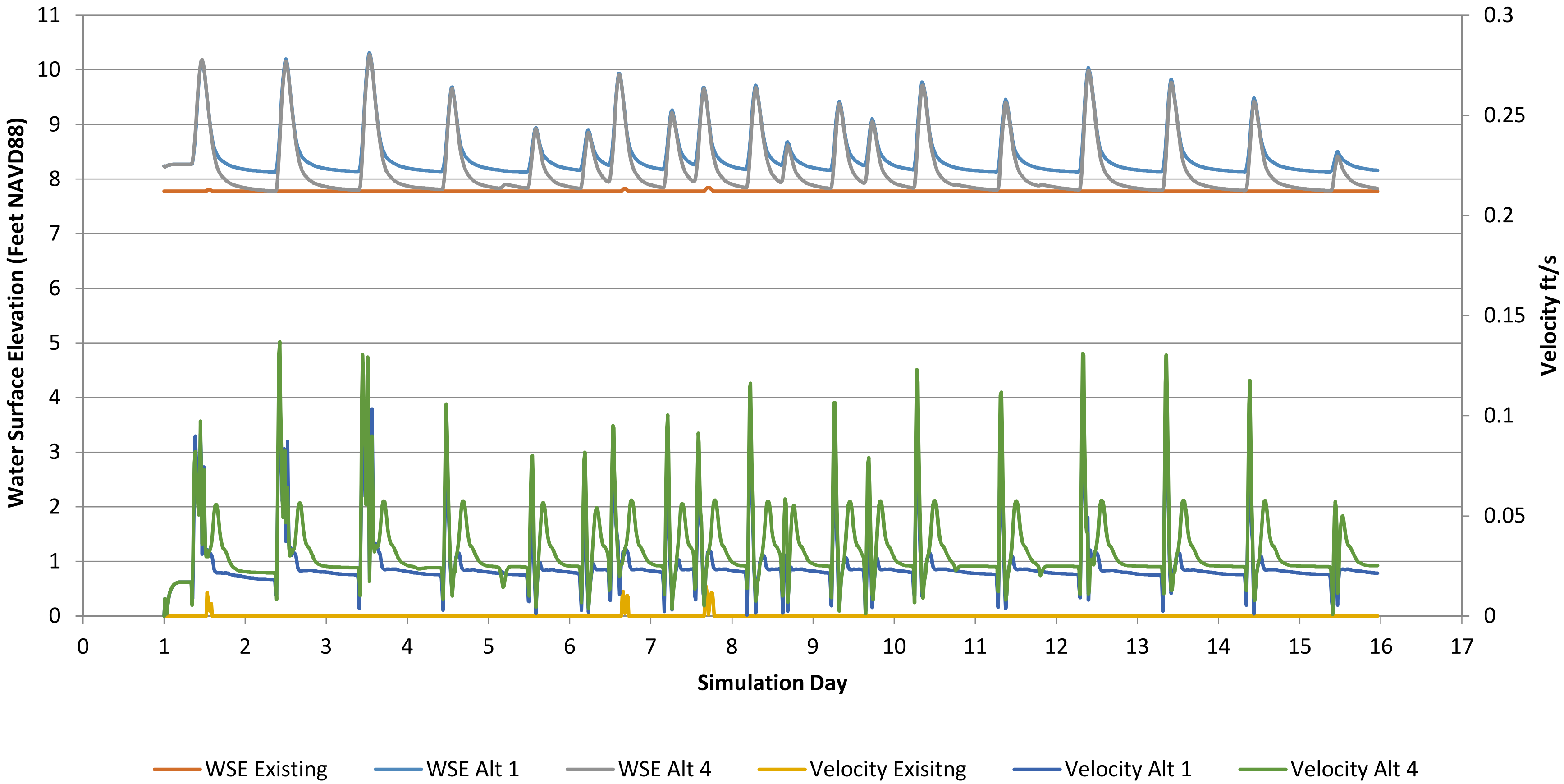
FIG. 18

FIG. 18

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 4 100 Year>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Fish Habitat Water Surface Elevation and Velocity Node 4 - Center of Marsh

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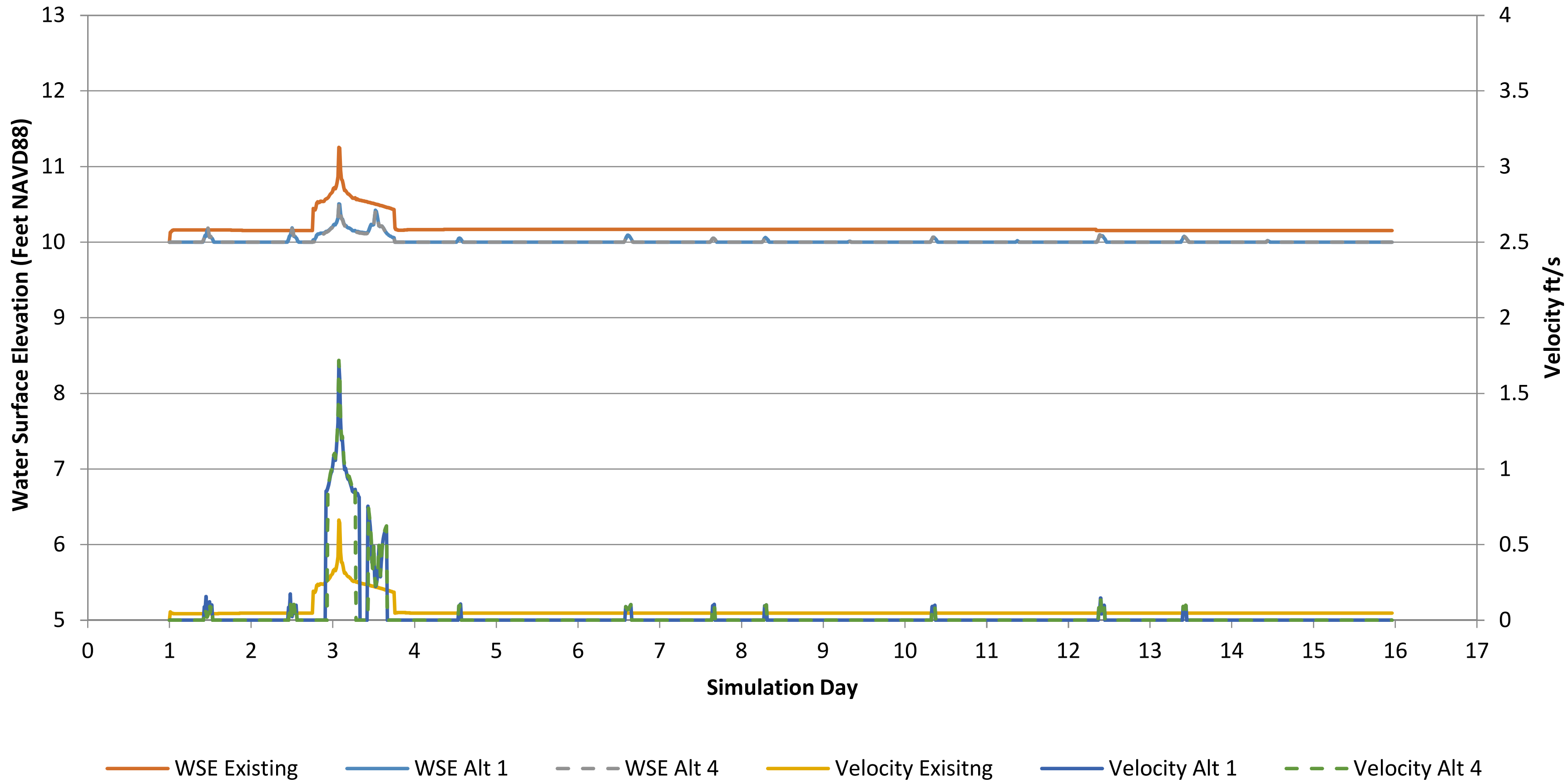
FIG. 19

FIG. 19

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 4 Low Flow>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 5 - Willow Creek Downstream of Hatchery

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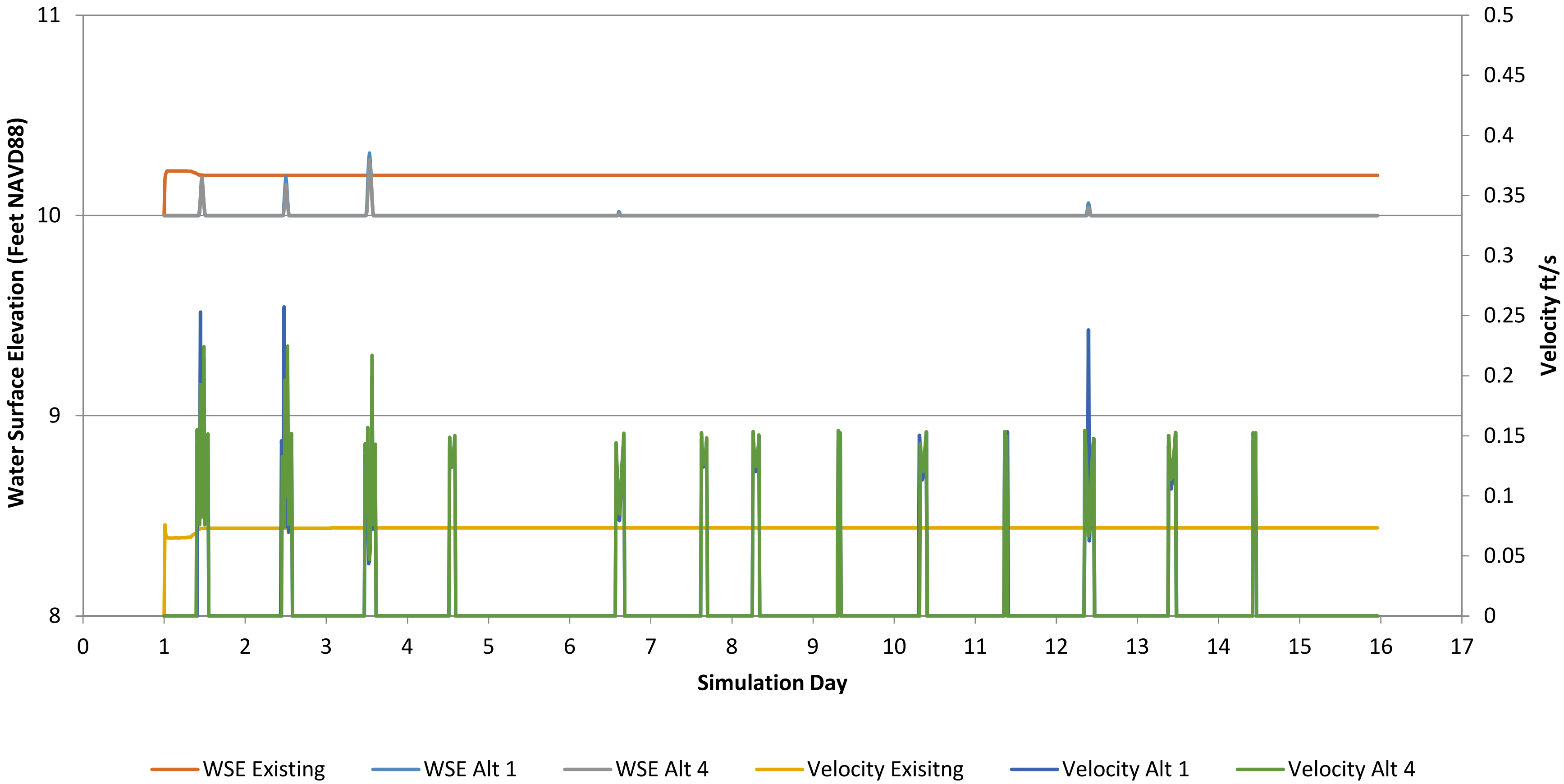
FIG. 20

FIG. 20



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Fish Habitat Water Surface Elevation and Velocity
Node 5 - Willow Creek Downstream of Hatchery

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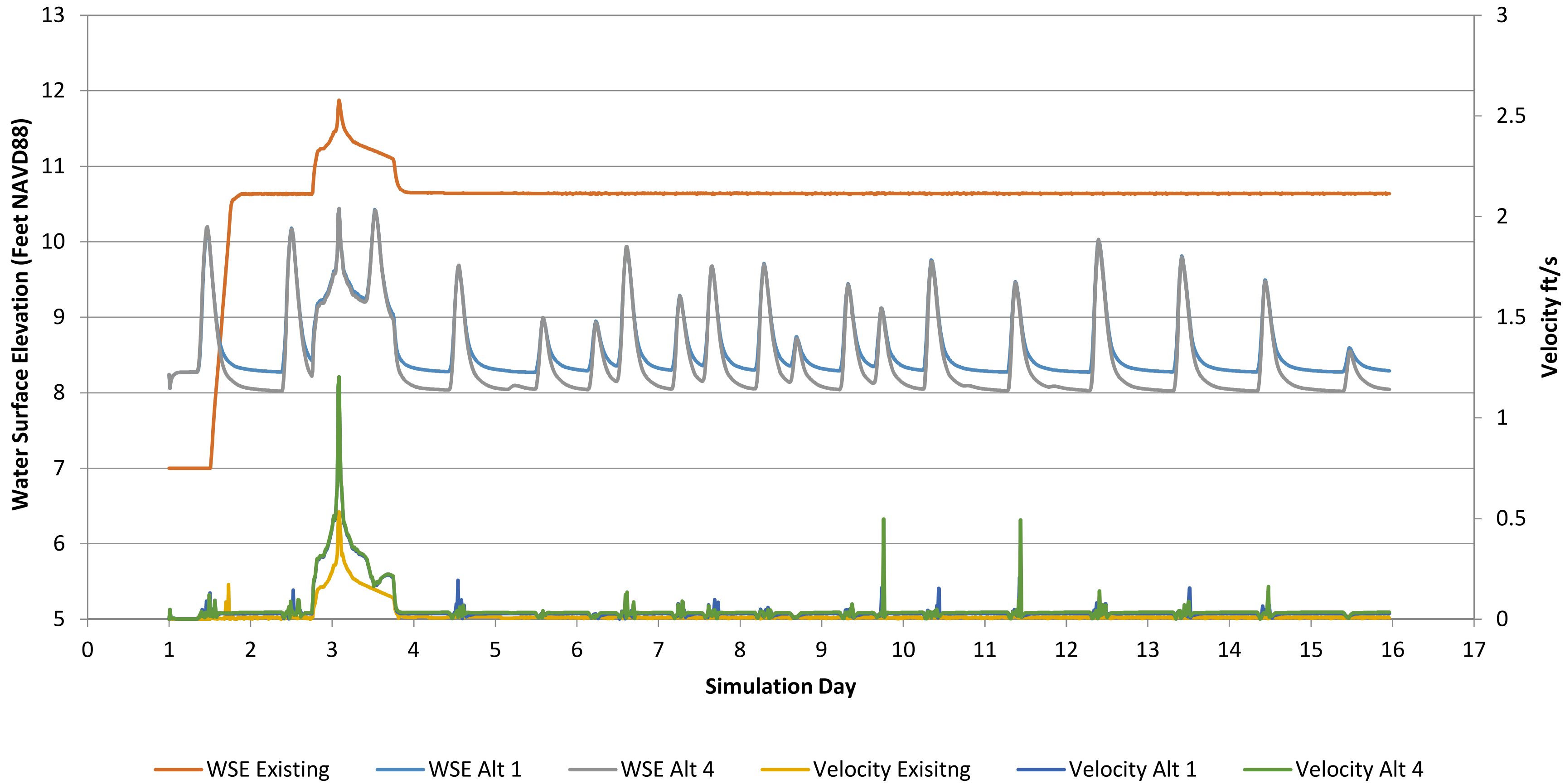
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 21

FIG. 21

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 5 Low Flow>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 6 - Shellabarger Creek Downstream of SR 104

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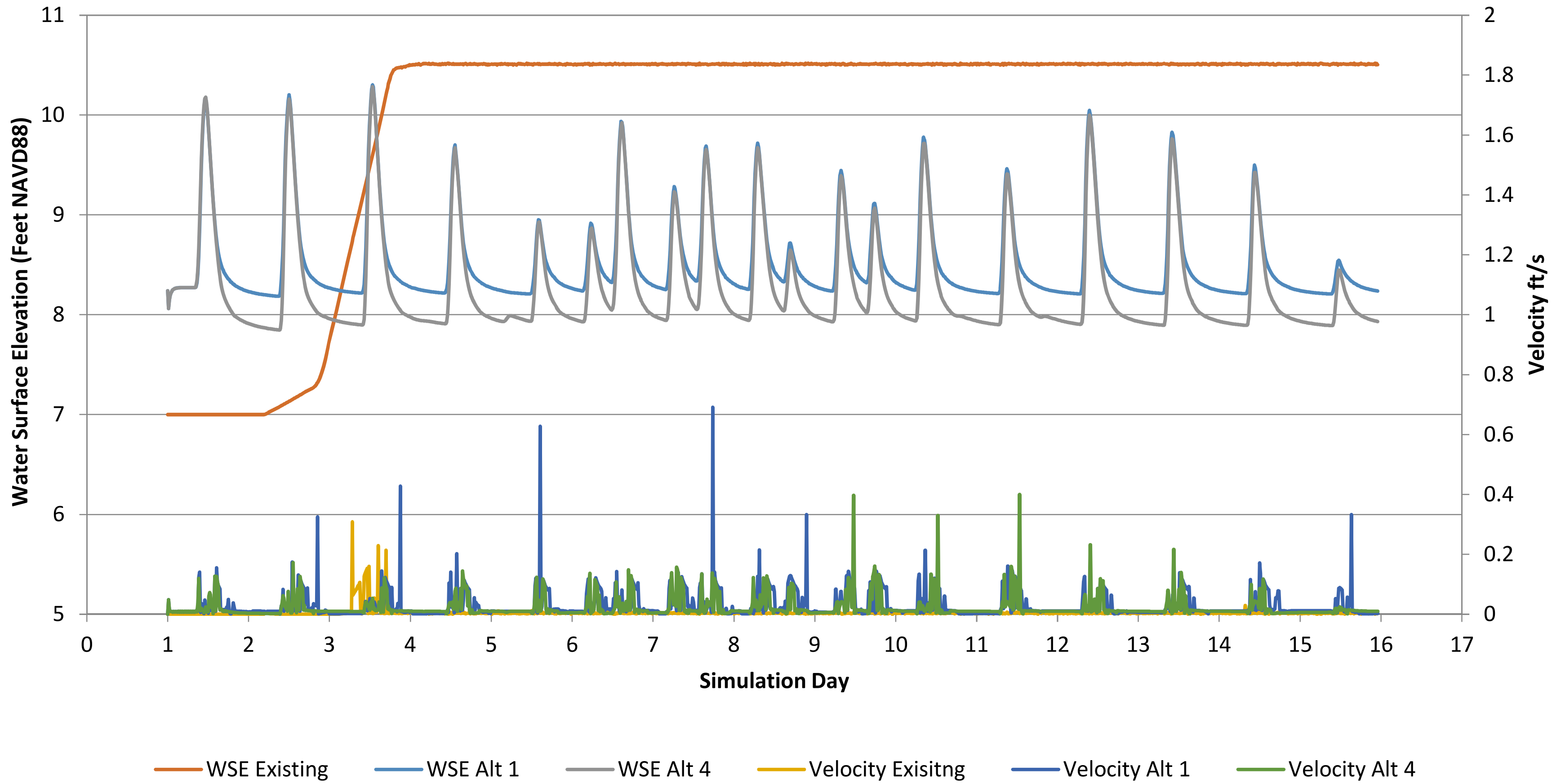
FIG. 22

FIG. 22

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 6 100 Year>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Habitat Water Surface Elevation and Velocity
Node 6 - Shellabarger Creek Downstream of SR 104

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FIG. 23

FIG. 23

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 6 Low Flow>

EXISTING CONDITIONS

ALTERNATIVE 1
LINEAR DAYLIGHT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 1
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 24A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\PreviousStudy\Figure24A_Existing_Alternative1_KingTide_SAIC_Depth.mxd Date: 3/10/2019 CCB

EXISTING CONDITIONS

ALTERNATIVE 1
LINEAR DAYLIGHT CHANNEL

Velocities

- 0.0 - 0.1 FT/S
- 0.1 - 0.2 FT/S
- 0.2 - 0.3 FT/S
- 0.3 - 0.4 FT/S
- 0.4 - 0.5 FT/S
- 0.5 - 0.6 FT/S
- 0.7 - 0.8 FT/S
- 0.8 - 0.9 FT/S
- 0.9 - 1.0 FT/S
- 1.0 - 2.0 FT/S
- 2.0 - 3.0 FT/S
- 3.0 - 4.0 FT/S
- 4.0 - 5.0 FT/S
- 5.0+ FT/S

EXISTING AND ALTERNATIVE 1 KING TIDE WITH SAIC 1% (100-YR) AEP INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N
W E
S

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

December 2018 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 24B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\PreviousStudy\Figure25A_Existing_Alternative4_KingTide_SAIC_Depth.mxd Date: 3/10/2019 CCB

EXISTING CONDITIONS

ALTERNATIVE 4
SINUOUS DAYLIGHT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 4
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N S W E

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2018 21-1-12588-050

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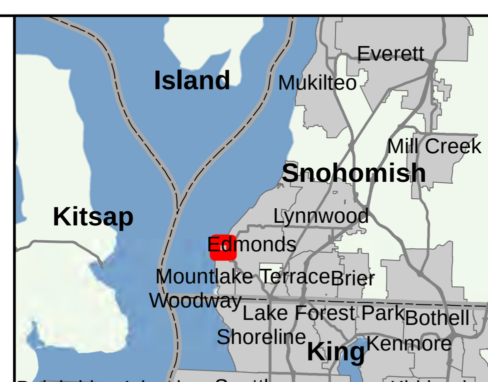
FIG. 25A

EXISTING CONDITIONS

ALTERNATIVE 4
SINUOUS DAYLIGHT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S



EXISTING AND ALTERNATIVE 4
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N S W E

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 25B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\PreviousStudy\Figure25B_Existing_Alternative4_KingTide_SAIC_Velocities.mxd Date: 3/10/2019 CCB

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\PreviousStudy\Figure26A_Existing_Alternative1_KingTide_Habitat_Depth.mxd Date: 3/10/2019 CCB

EXISTING CONDITIONS

ALTERNATIVE 1
LINEAR DAYLIGHT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 1
KING TIDE WITH LATE SPRING HABITAT
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2018 | 21-1-12588-050

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 26A

EXISTING CONDITIONS

ALTERNATIVE 1
LINEAR DAYLIGHT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 1
KING TIDE WITH LATE SPRING HABITAT
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

December 2018 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 26B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\PreviousStudy\Figure26B_Existing_Alternative1_KingTide_Habitat_Velocities.mxd Date: 3/10/2019 CCB

EXISTING CONDITIONS

ALTERNATIVE 4
SINUOUS DAYLIGHT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 4 KING TIDE WITH LATE SPRING HABITAT INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N
W E
S

0 450 900
Feet

CITY OF EDMONDS
Est. 1890

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2018 | 21-1-12588-050

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 27A

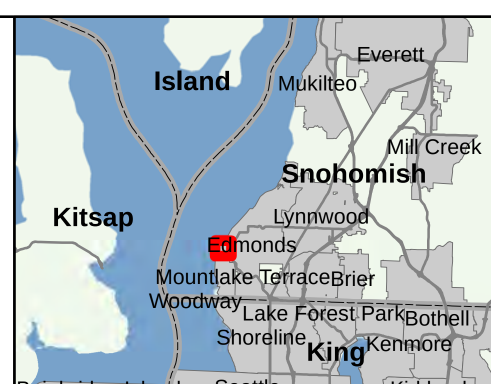
Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\PreviousStudy\Figure27A_Existing_Alternative4_KingTide_Habitat_Depth.mxd Date: 3/10/2019 CCB

EXISTING CONDITIONS

ALTERNATIVE 4
SINUOUS DAYLIGHT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S



EXISTING AND ALTERNATIVE 4
KING TIDE WITH LATE SPRING HABITAT
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

December 2018 | 21-1-12588-050

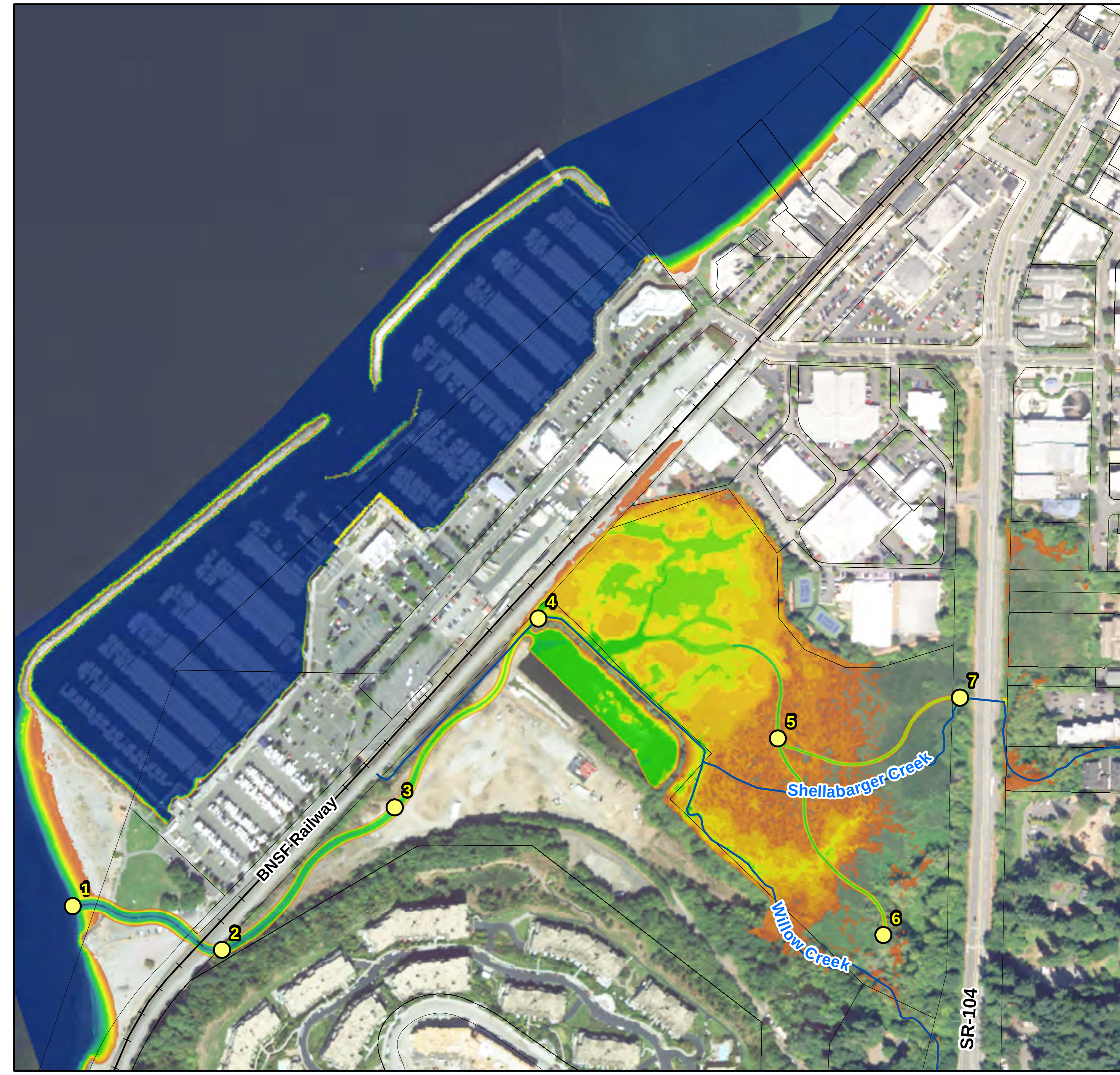
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 27B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\PreviousStudy\Figure27B_Existing_Alternative4_KingTide_Habitat_Velocities.mxd Date: 3/10/2019 CCB

Filename: I:\EFI21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure16A_Existing_Alternative5_KingTide_Habitat_Depth.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS



ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

**EXISTING AND ALTERNATIVE 5
KING TIDE WITH
LATE SPRING FISH
HABITAT INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)**

N
W E
S

0 450 900
Feet

CITY OF EDMONDS
Est. 1890

**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 28A

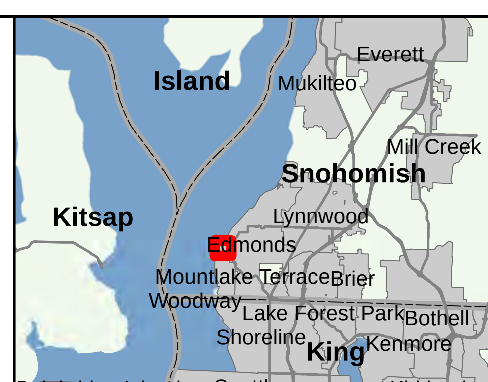
Filename: I:\EFI21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure16B_Existing_Alternative5_KingTide_Habitat_Velocity.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S



EXISTING AND ALTERNATIVE 5 KING TIDE WITH LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

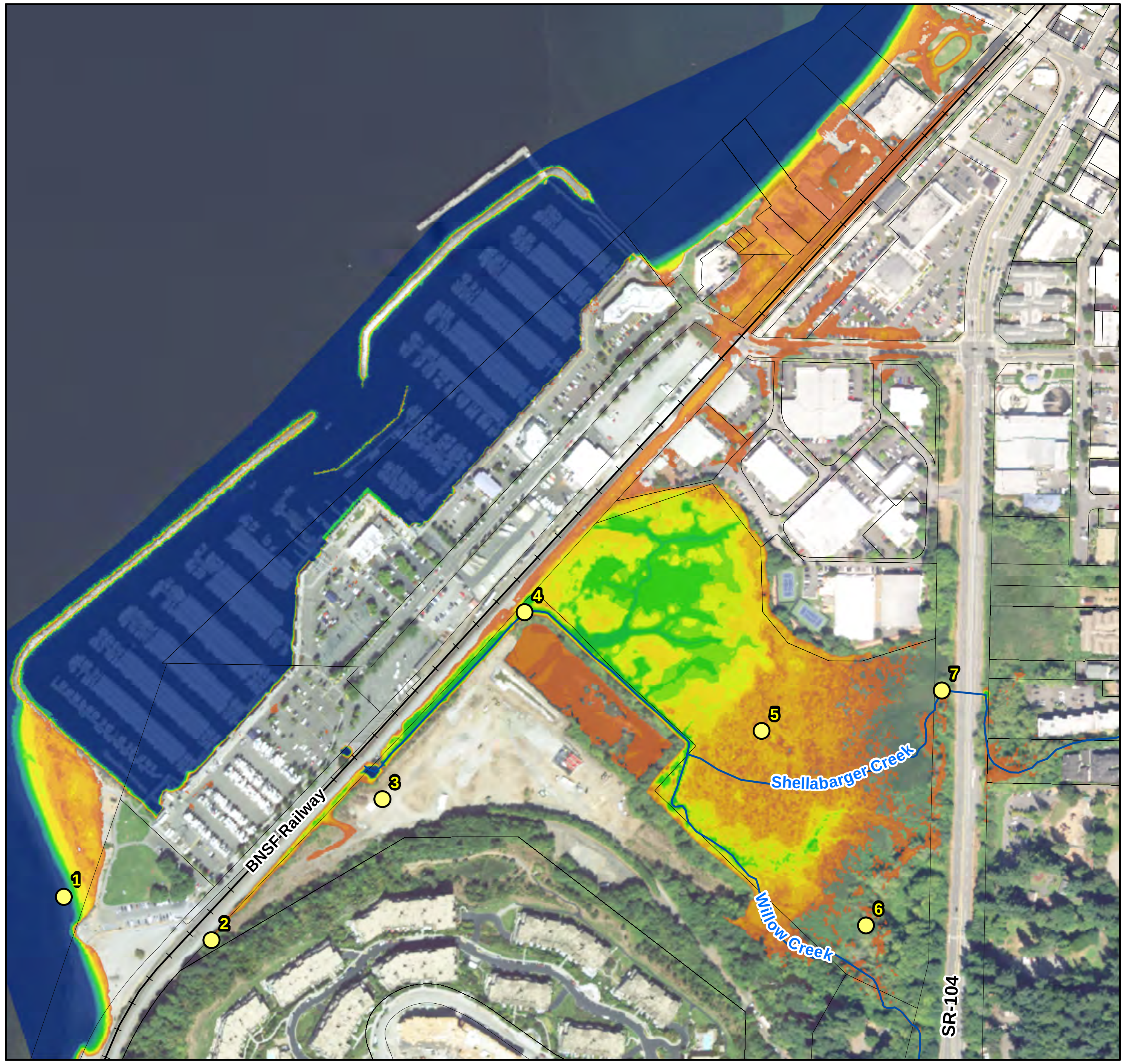
0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 28B



EXISTING CONDITIONS

ALTERNATIVE 5 MEANDERING DAYLIGHT CHANNEL WITH FISH HABITAT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 5 KING TIDE WITH SLR 2100 AND LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N S W E

CITY OF EDMONDS Est. 1890

0 450 900
Feet

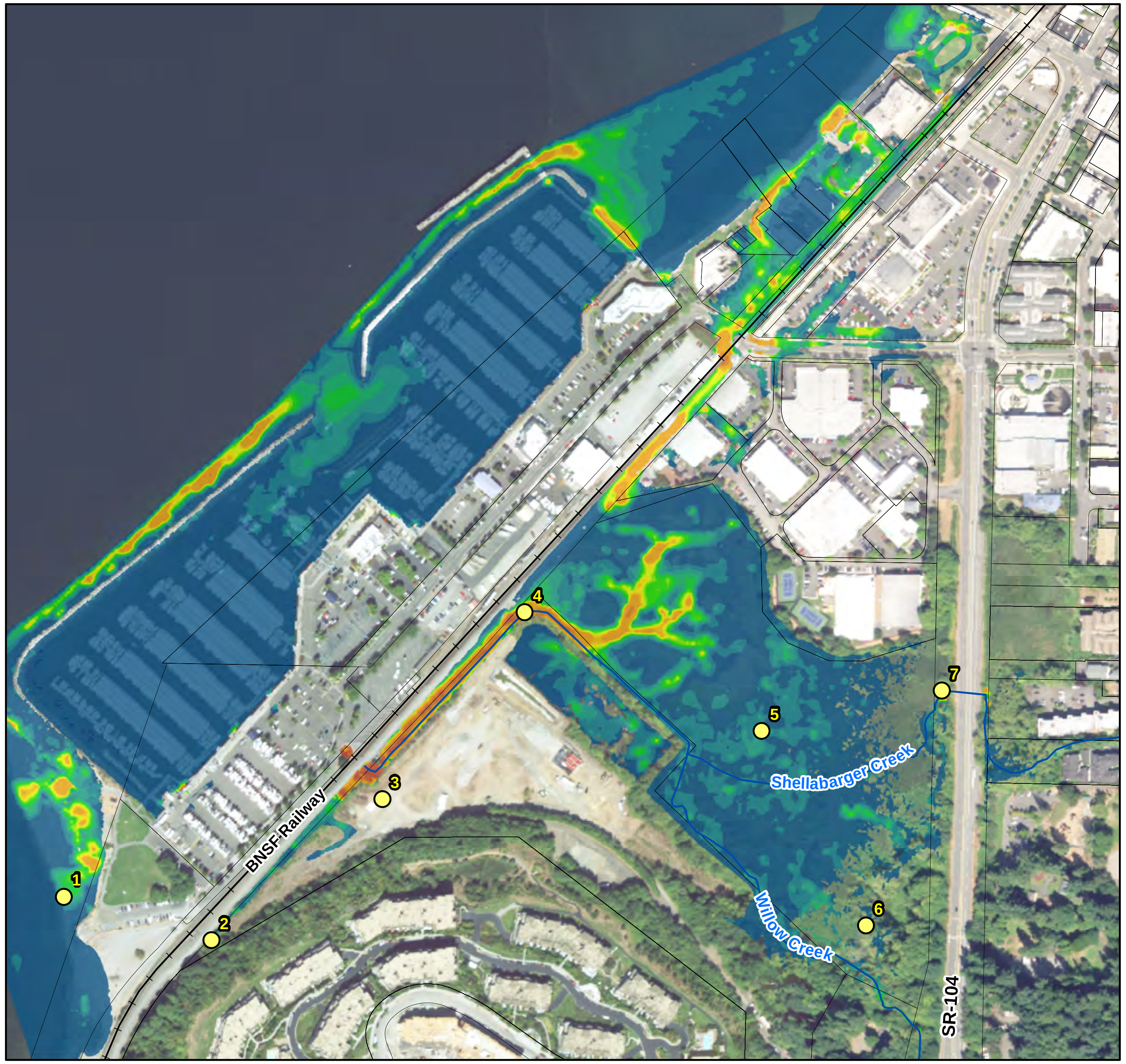
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 29A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure17A_Existing_Alternative5_KingTideSLR2100_Habitat_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 5 MEANDERING DAYLIGHT CHANNEL WITH FISH HABITAT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 5 KING TIDE WITH SLR-2100 AND LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900 Feet

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WASHINGTON

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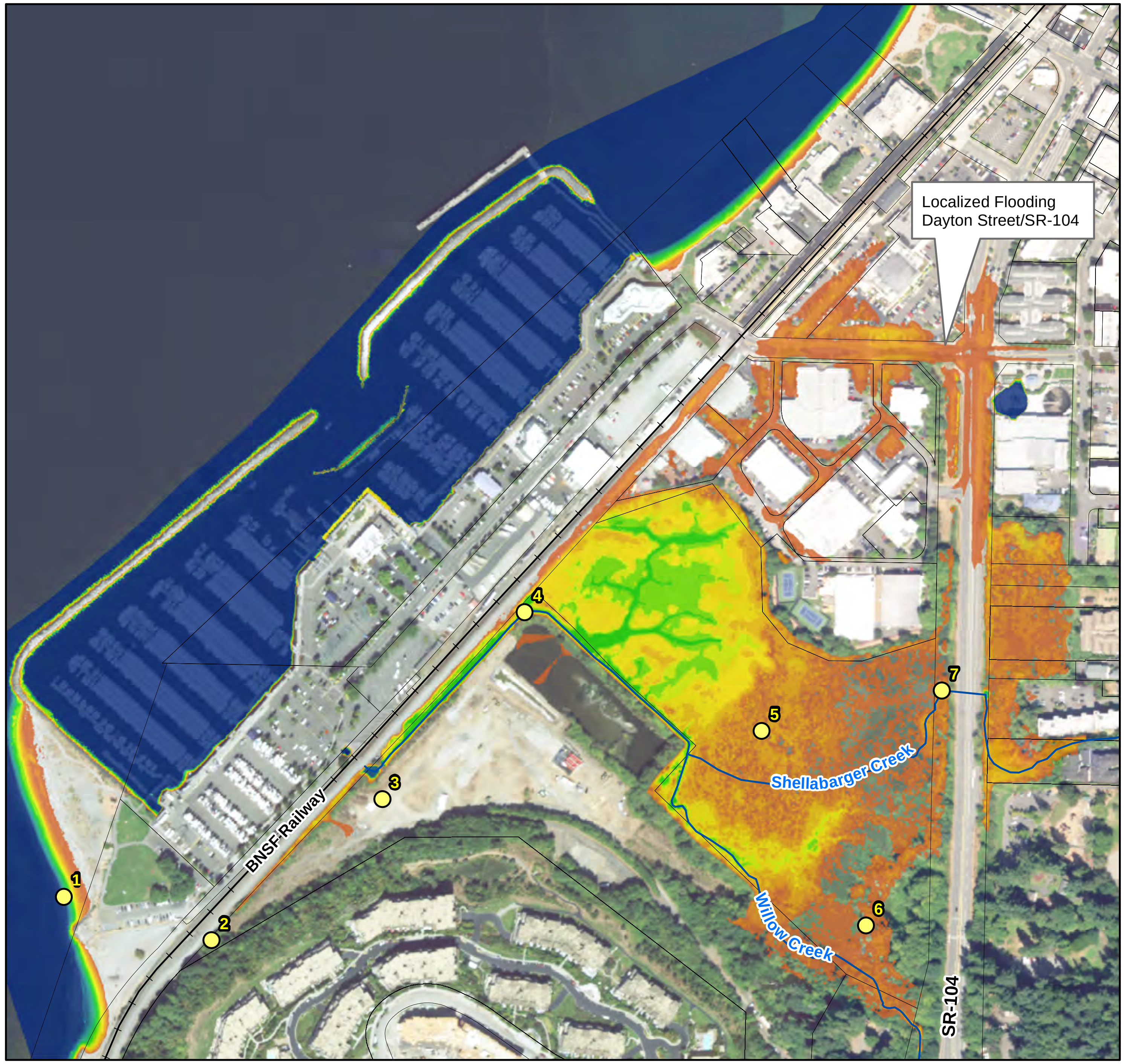
FIG. 29B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure17B_Existing_Alternative5_KingTideSLR2100_Habitat_Velocity.mxd Date: 12/20/2018 CCB

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure18A_Existing_Alternative5_KingTide_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 5
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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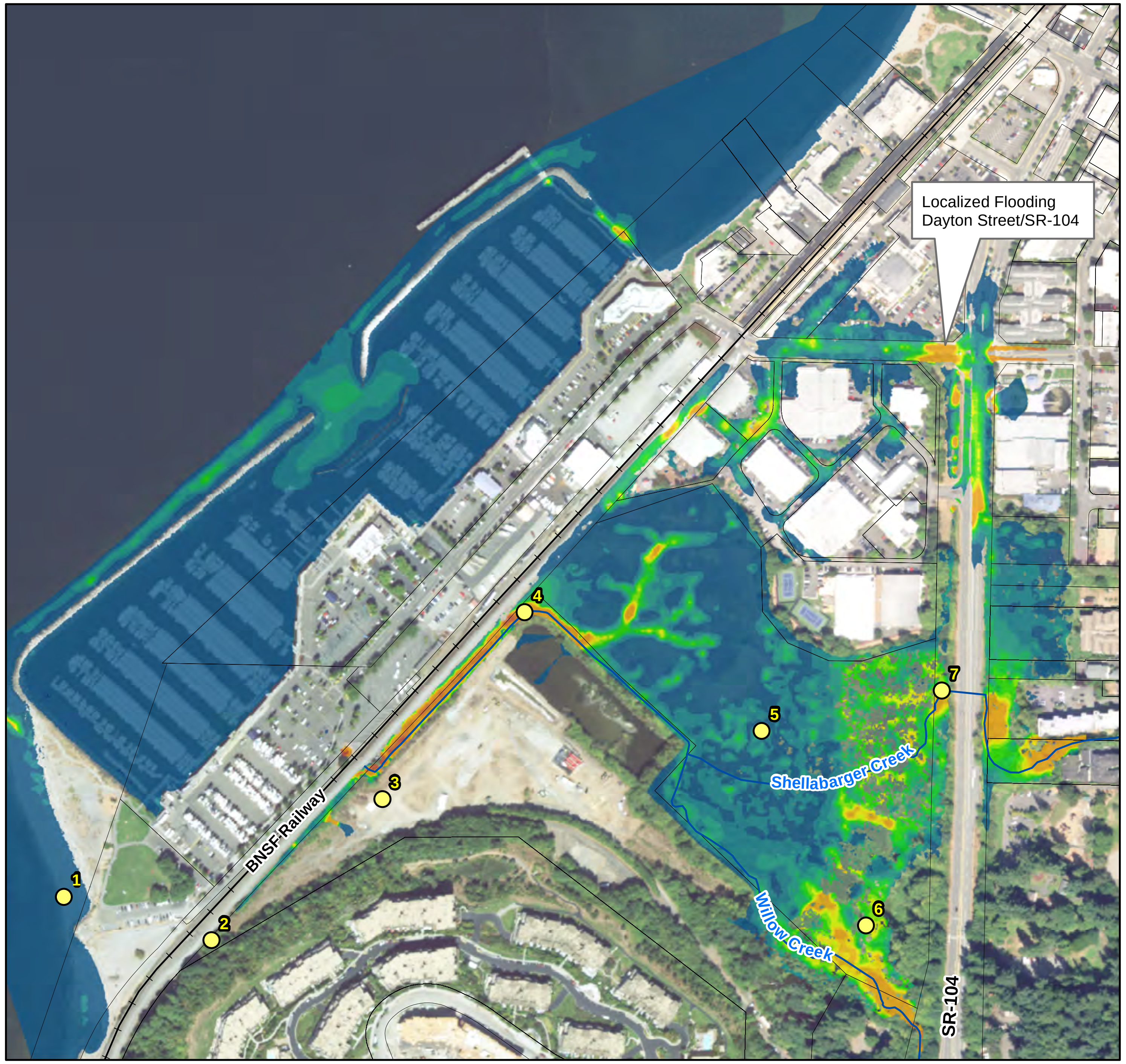
FIG. 30A



EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 5
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N
W E
S

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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FIG. 30B

Filename: I:\EFI21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure18B_Existing_Alternative5_KingTide_SAIC_Velocities.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS

ALTERNATIVE 5 MEANDERING DAYLIGHT CHANNEL WITH FISH HABITAT CHANNEL

Inundation Depths

- 0 - 0.5 FT
- 0.5 - 1 FT
- 1 - 1.5 FT
- 1.5 - 2 FT
- 2 - 2.5 FT
- 2.5 - 3 FT
- 3 - 3.5 FT
- 3.5 - 4 FT
- 4 - 4.5 FT
- 4.5 - 5 FT
- 5 - 5.5 FT
- 5.5 - 6 FT
- 6 - 6.5 FT
- 6.5+ FT

EXISTING AND ALTERNATIVE 5 KING TIDE WITH SLR-2100 AND SAIC 1% (100-YR) AEP INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N W E S

0 450 900 Feet

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WASHINGTON

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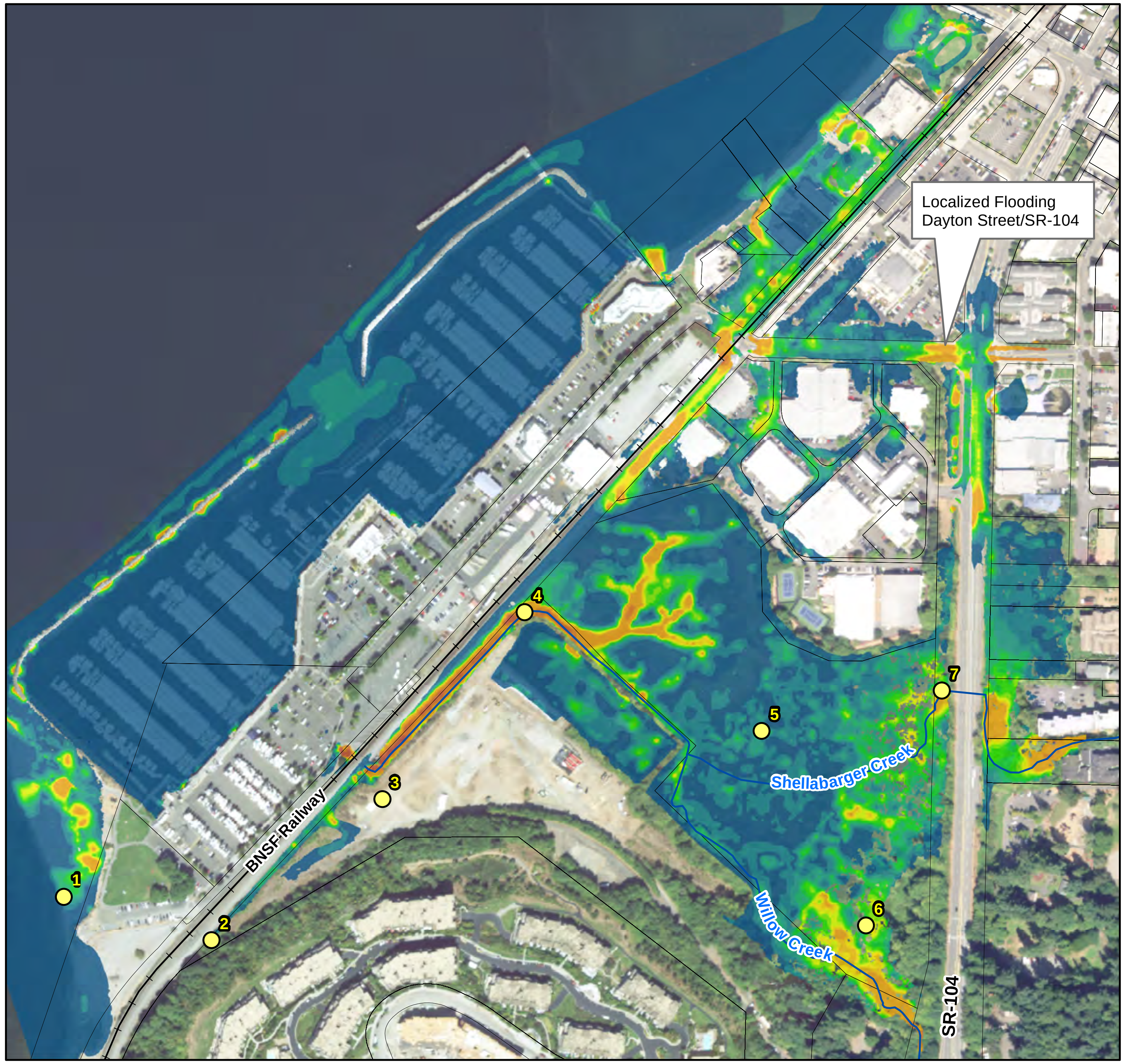
FIG. 31A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure19A_Existing_Alternative5_KingTideSLR2100_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 5 KING TIDE WITH SLR-2100 AND SAIC 1% (100-YR) AEP INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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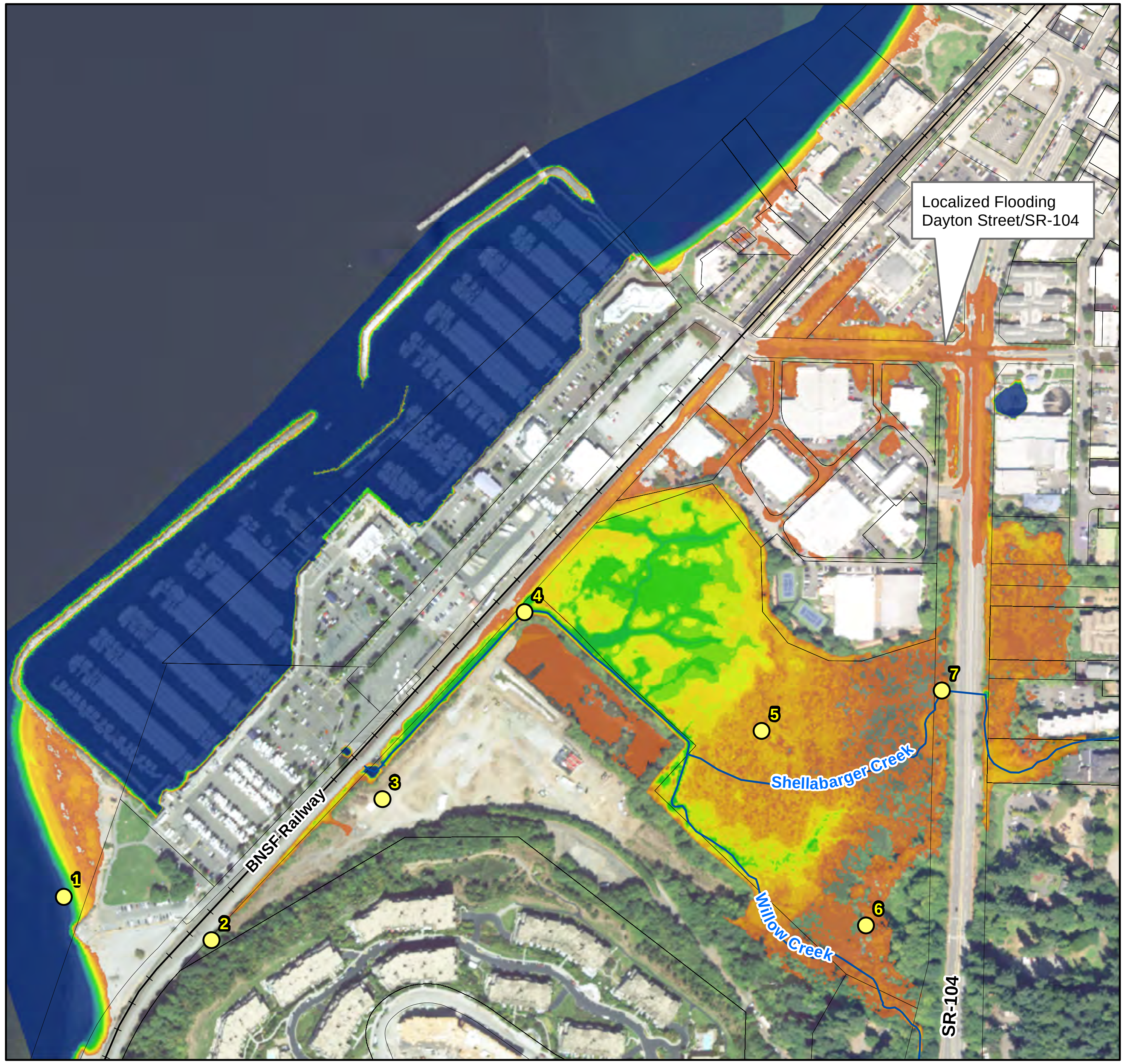
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 31B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure19B_Existing_Alternative5_KingTideSLR2100_SAIC_Velocities.mxd Date: 12/20/2018 CCB

Filename: I:\EFI21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure22A_Existing_Alternative5_StormSurge_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 5 STORM SURGE TIDE AND SAIC 1% (100-YR) INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WASHINGTON

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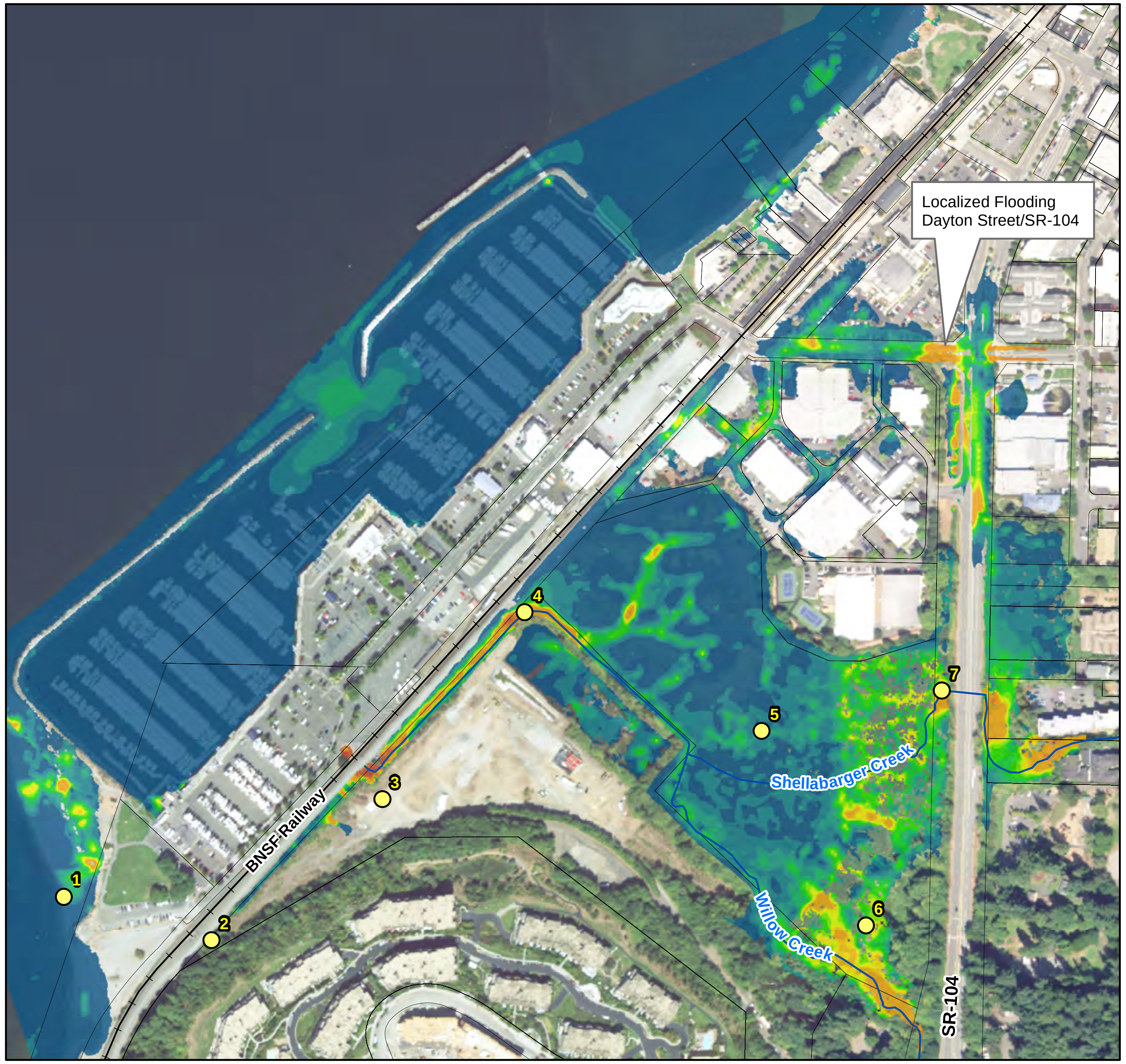
FIG. 32A



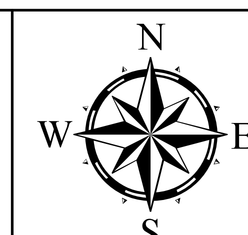
EXISTING CONDITIONS

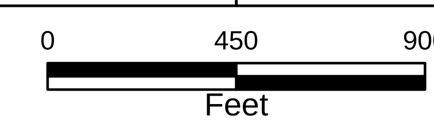
ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 5 STORM SURGE TIDE AND SAIC 1% (100-YR) INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)





WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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SHANNON & WILSON, INC.
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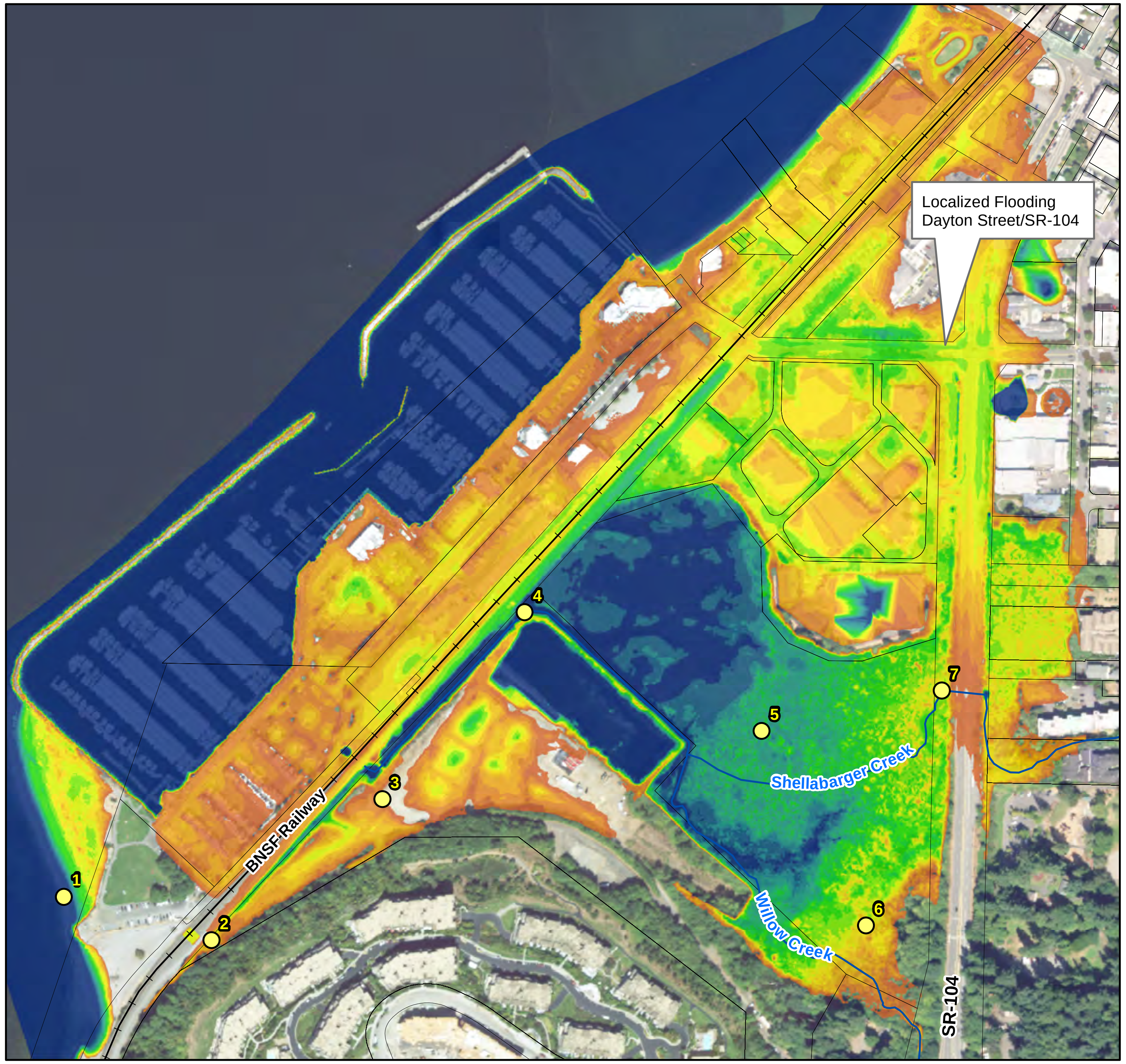
FIG. 32B



EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Inundation Depths

- 0 - 0.5 FT
- 0.5 - 1 FT
- 1 - 1.5 FT
- 1.5 - 2 FT
- 2 - 2.5 FT
- 2.5 - 3 FT
- 3 - 3.5 FT
- 3.5 - 4 FT
- 4 - 4.5 FT
- 4.5 - 5 FT
- 5 - 5.5 FT
- 5.5 - 6 FT
- 6 - 6.5 FT
- 6.5+ FT

**EXISTING AND ALTERNATIVE 5
STORM SURGE TIDE WITH SLR-2100
AND SAIC 1% (100-YR)
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)**

N / S / E / W

0 450 900
Feet

**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 33A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure23A_Existing_Alternatives5_StormSurgeSLR2100_SAIC_Depth.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS

ALTERNATIVE 5
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

**EXISTING AND ALTERNATIVE 5
STORM SURGE TIDE WITH SLR-2100
AND SAIC 1% (100-YR)
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)**

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

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SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 33B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure23B_Existing_Alternative5_StormSurgeSLR2100_SAIC_Velocities.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Inundation Depths

- 0 - 0.5 FT
- 0.5 - 1 FT
- 1 - 1.5 FT
- 1.5 - 2 FT
- 2 - 2.5 FT
- 2.5 - 3 FT
- 3 - 3.5 FT
- 3.5 - 4 FT
- 4 - 4.5 FT
- 4.5 - 5 FT
- 5 - 5.5 FT
- 5.5 - 6 FT
- 6 - 6.5 FT
- 6.5+ FT

EXISTING AND ALTERNATIVE 6 KING TIDE WITH LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N W E S

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 34A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure26A_Existing_Alternative6_KingTide_Habitat_Depth.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

**EXISTING AND ALTERNATIVE 6
KING TIDE WITH
LATE SPRING FISH
HABITAT INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)**

N W E S

0 450 900
Feet

**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

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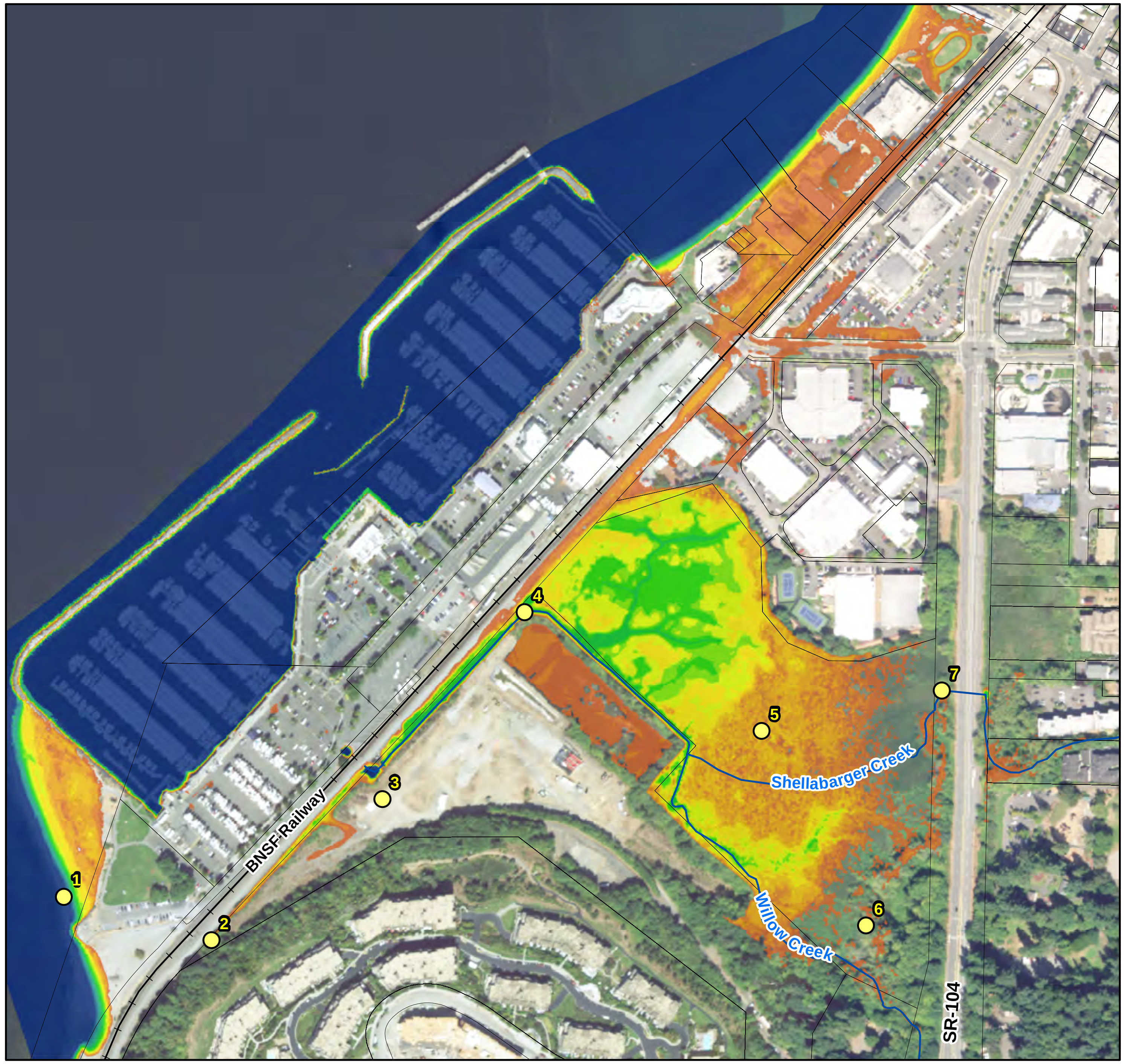
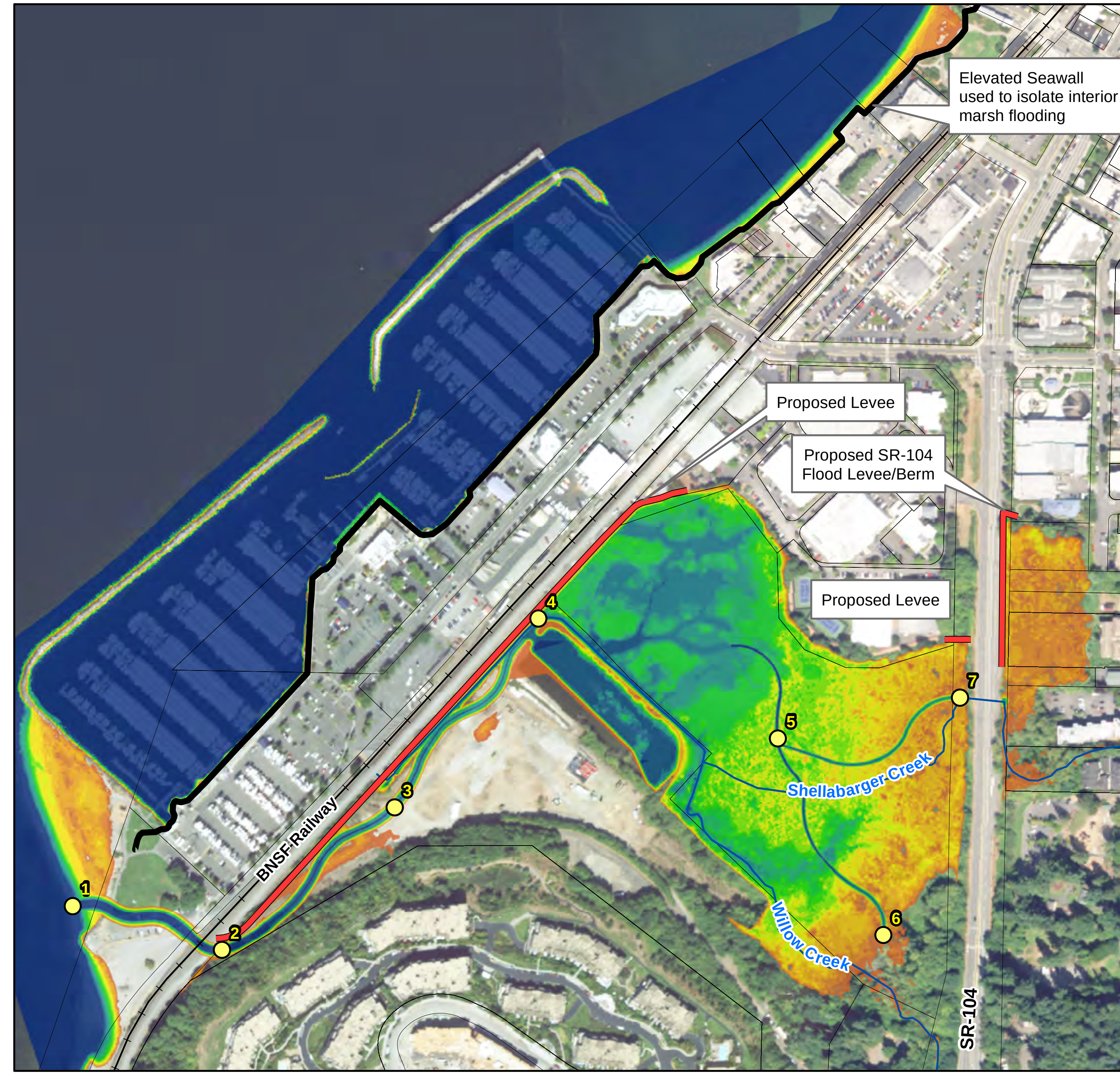
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 34B

Filename: I:\EFI21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure26B_Existing_Alternative6_KingTide_Habitat_Velocity.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS



ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

**EXISTING AND ALTERNATIVE 6
KING TIDE WITH SLR-2100
AND LATE SPRING FISH
HABITAT INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)**

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

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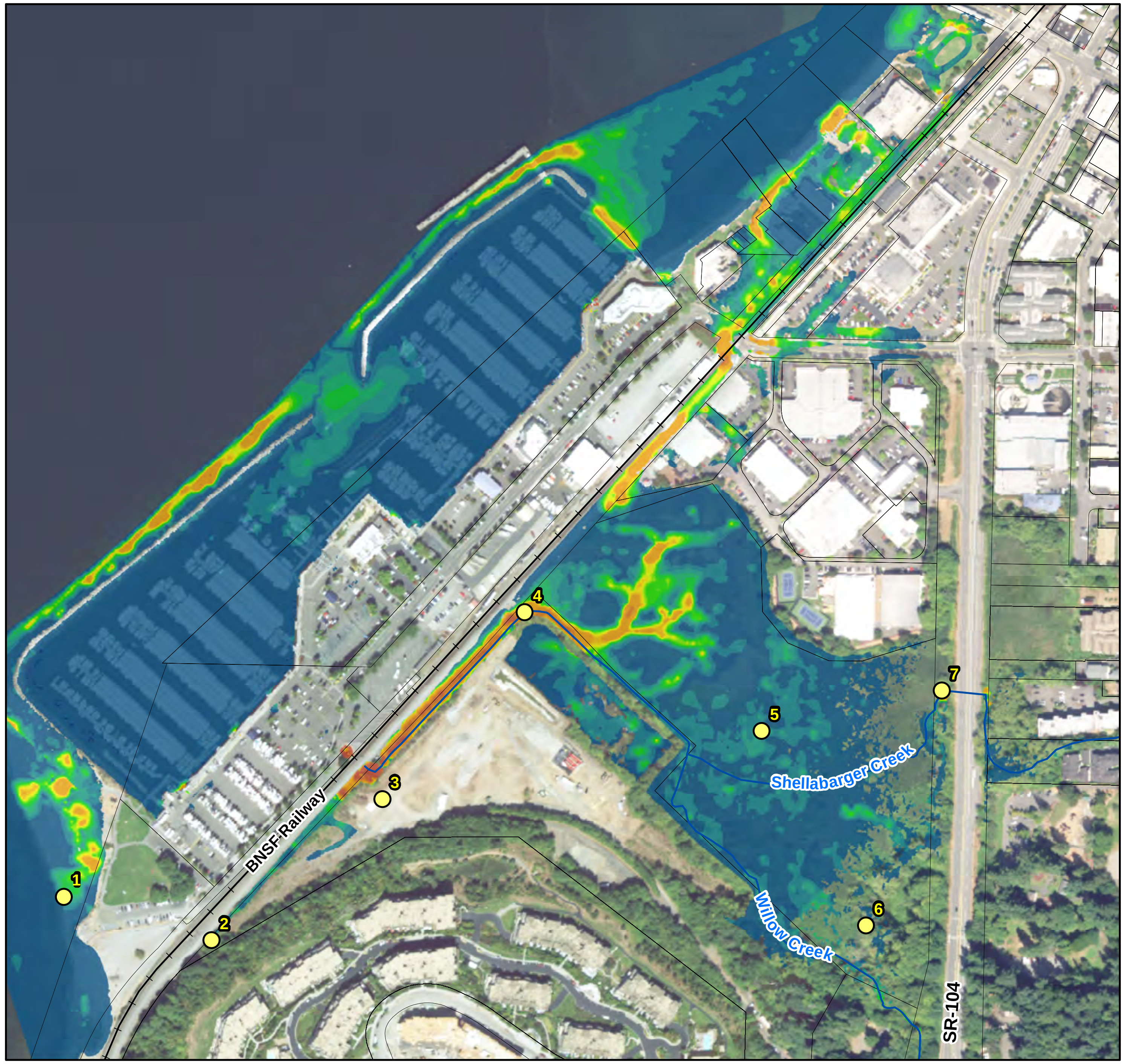
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 35A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure27A_Existing_Alternative6_KingTideSLR2100_Habitat_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Velocities

- 0.0 - 0.1 FT/S
- 0.1 - 0.2 FT/S
- 0.2 - 0.3 FT/S
- 0.3 - 0.4 FT/S
- 0.4 - 0.5 FT/S
- 0.5 - 0.6 FT/S
- 0.7 - 0.8 FT/S
- 0.8 - 0.9 FT/S
- 0.9 - 1.0 FT/S
- 1.0 - 2.0 FT/S
- 2.0 - 3.0 FT/S
- 3.0 - 4.0 FT/S
- 4.0 - 5.0 FT/S
- 5.0+ FT/S

EXISTING AND ALTERNATIVE 6 KING TIDE WITH SLR-2100 AND LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N S W E

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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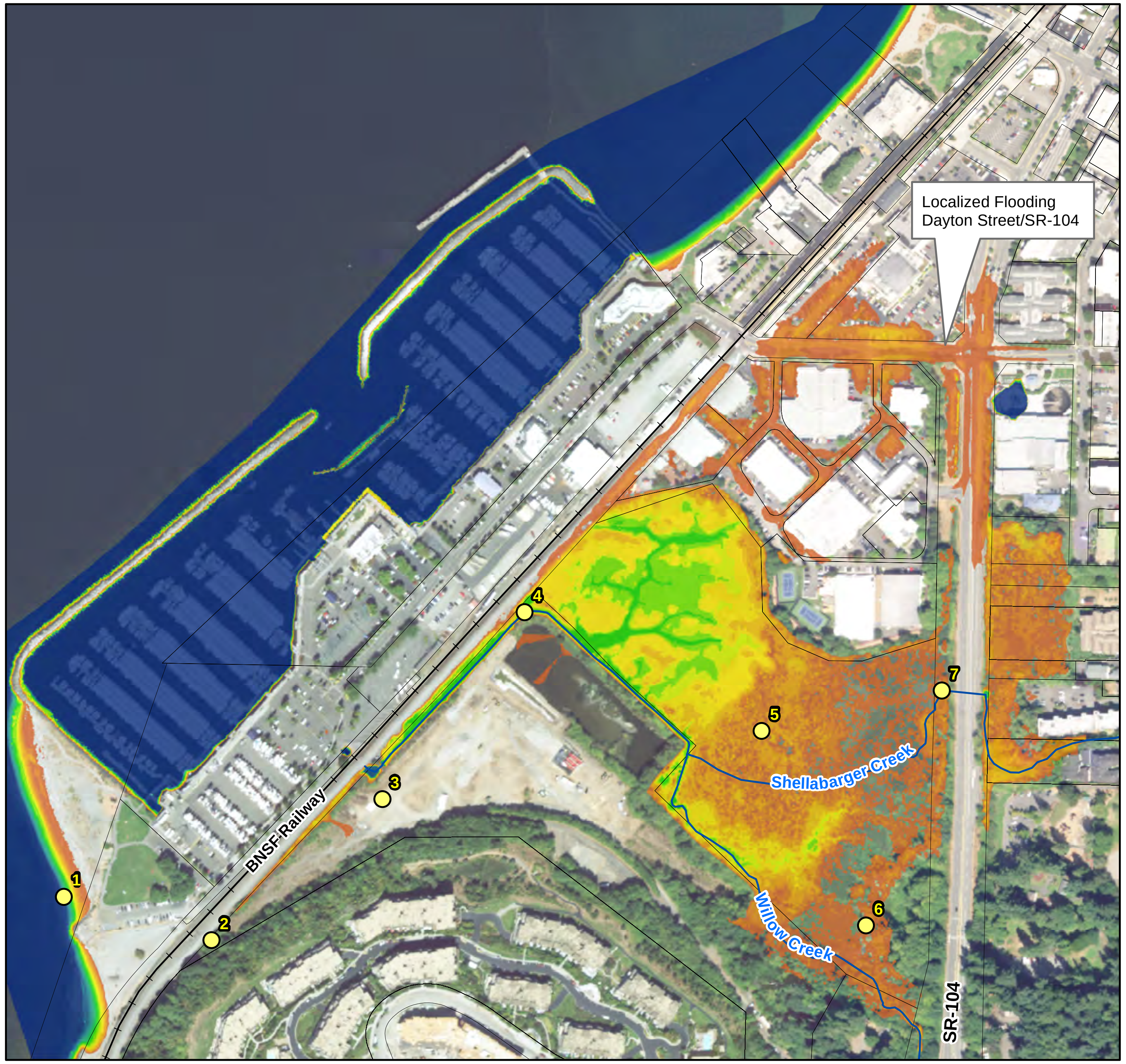
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 35B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure27B_Existing_Alternative6_KingTideSLR2100_Habitat_Velocity.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Inundation Depths

- 0 - 0.5 FT
- 0.5 - 1 FT
- 1 - 1.5 FT
- 1.5 - 2 FT
- 2 - 2.5 FT
- 2.5 - 3 FT
- 3 - 3.5 FT
- 3.5 - 4 FT
- 4 - 4.5 FT
- 4.5 - 5 FT
- 5 - 5.5 FT
- 5.5 - 6 FT
- 6 - 6.5 FT
- 6.5+ FT

EXISTING AND ALTERNATIVE 6
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
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EDMONDS, WASHINGTON

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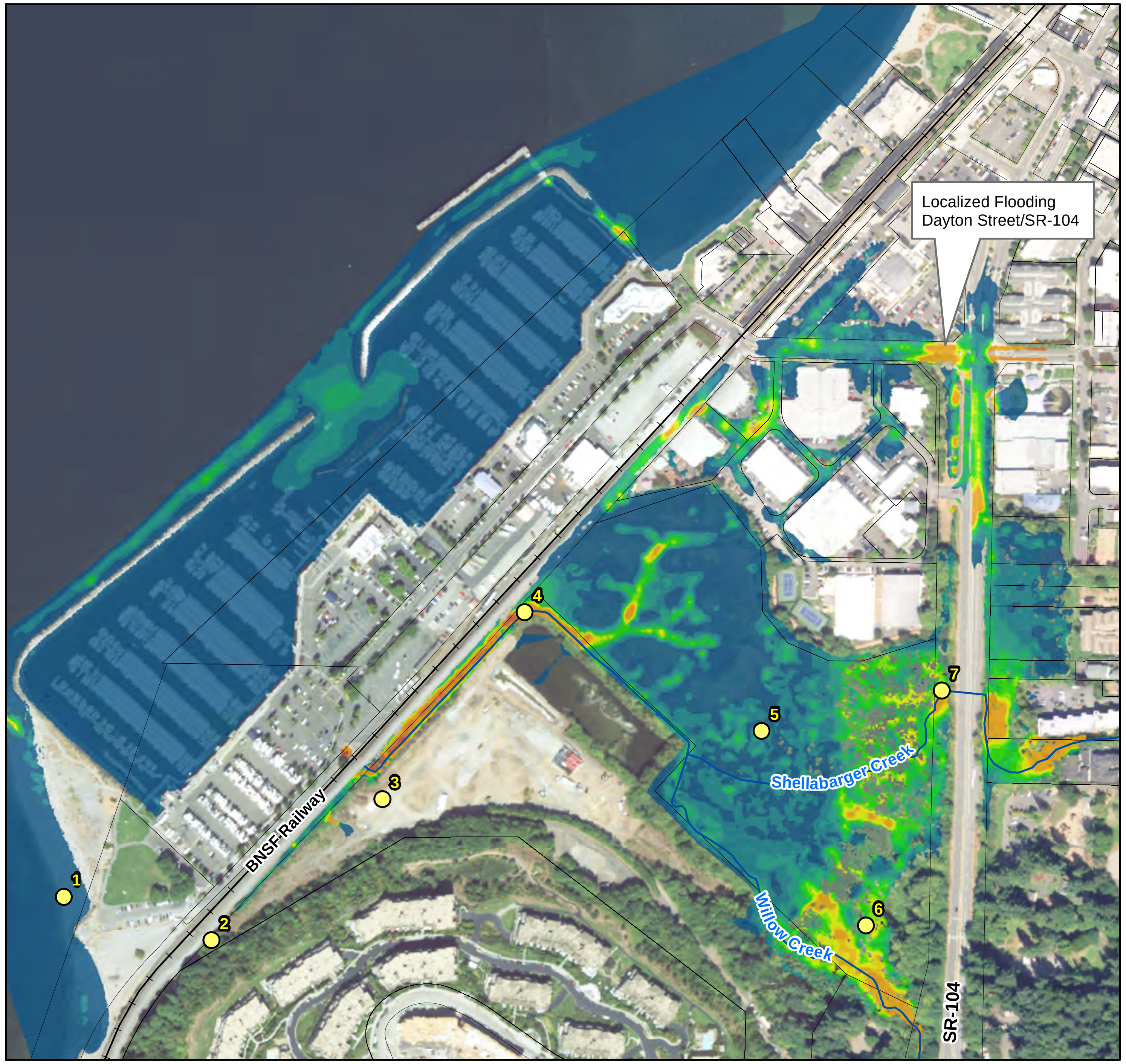
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 36A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure28A_Existing_Alternative6_KingTide_SAIC_Depth.mxd   Date: 12/20/2018   CCB



EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 6
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N
W E
S

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

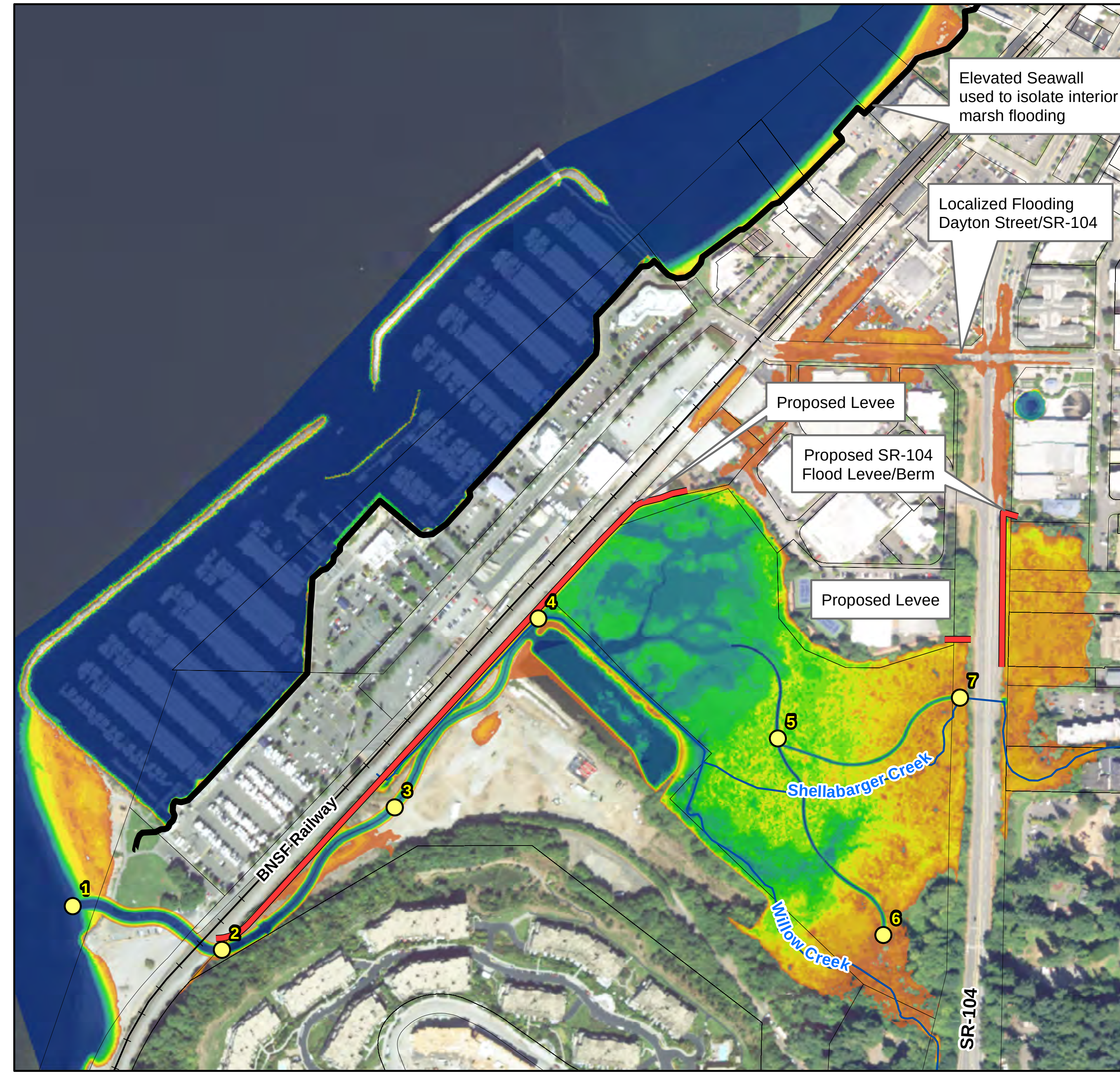
March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 36B

Filename: I:\EFI21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure28B_Existing_Alternative6_KingTide_SAIC_Velocities.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS



ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

**EXISTING AND ALTERNATIVE 6
KING TIDE WITH SLR-2100 AND
SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)**

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

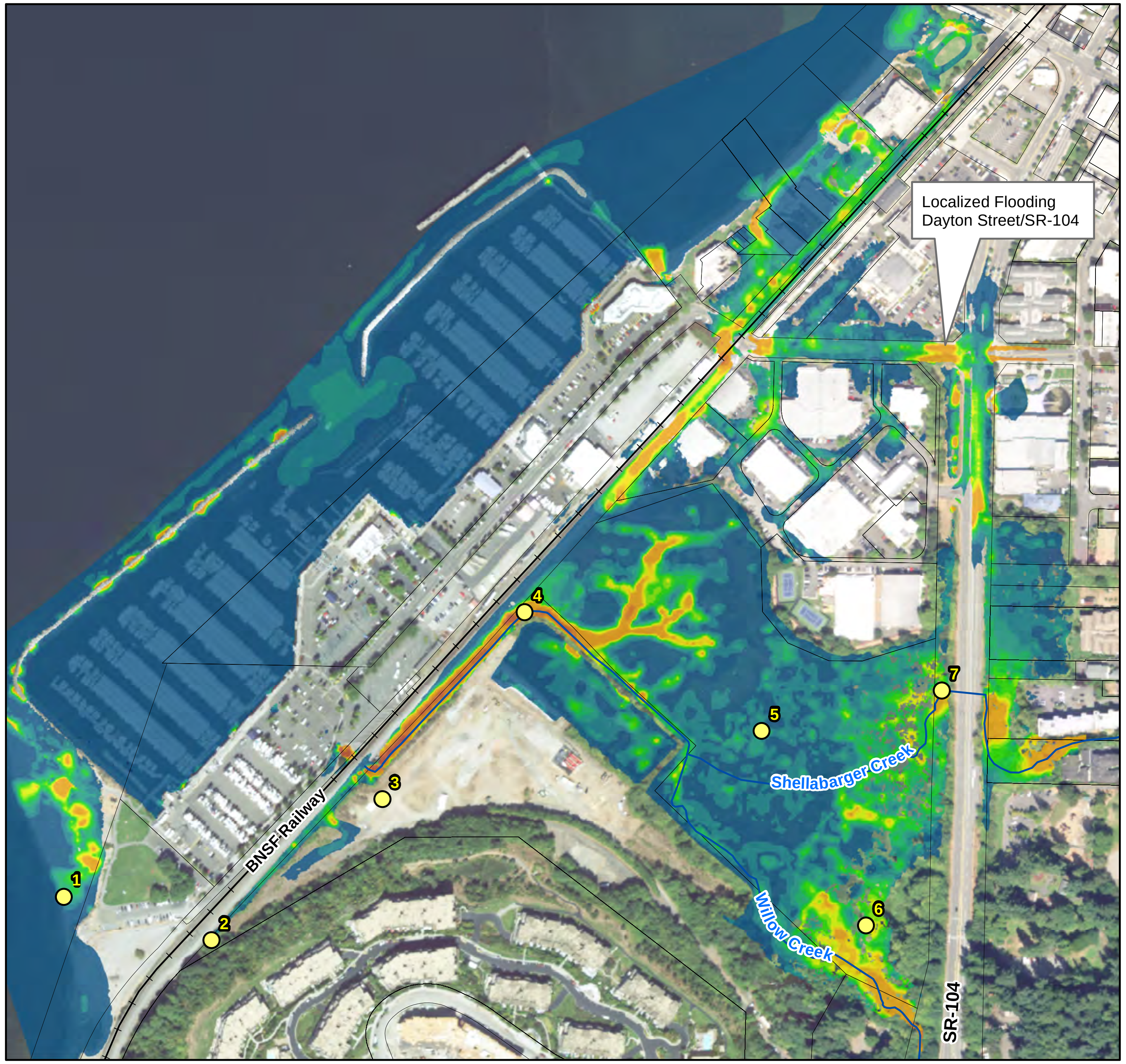
**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

March 2019 21-1-12588-050

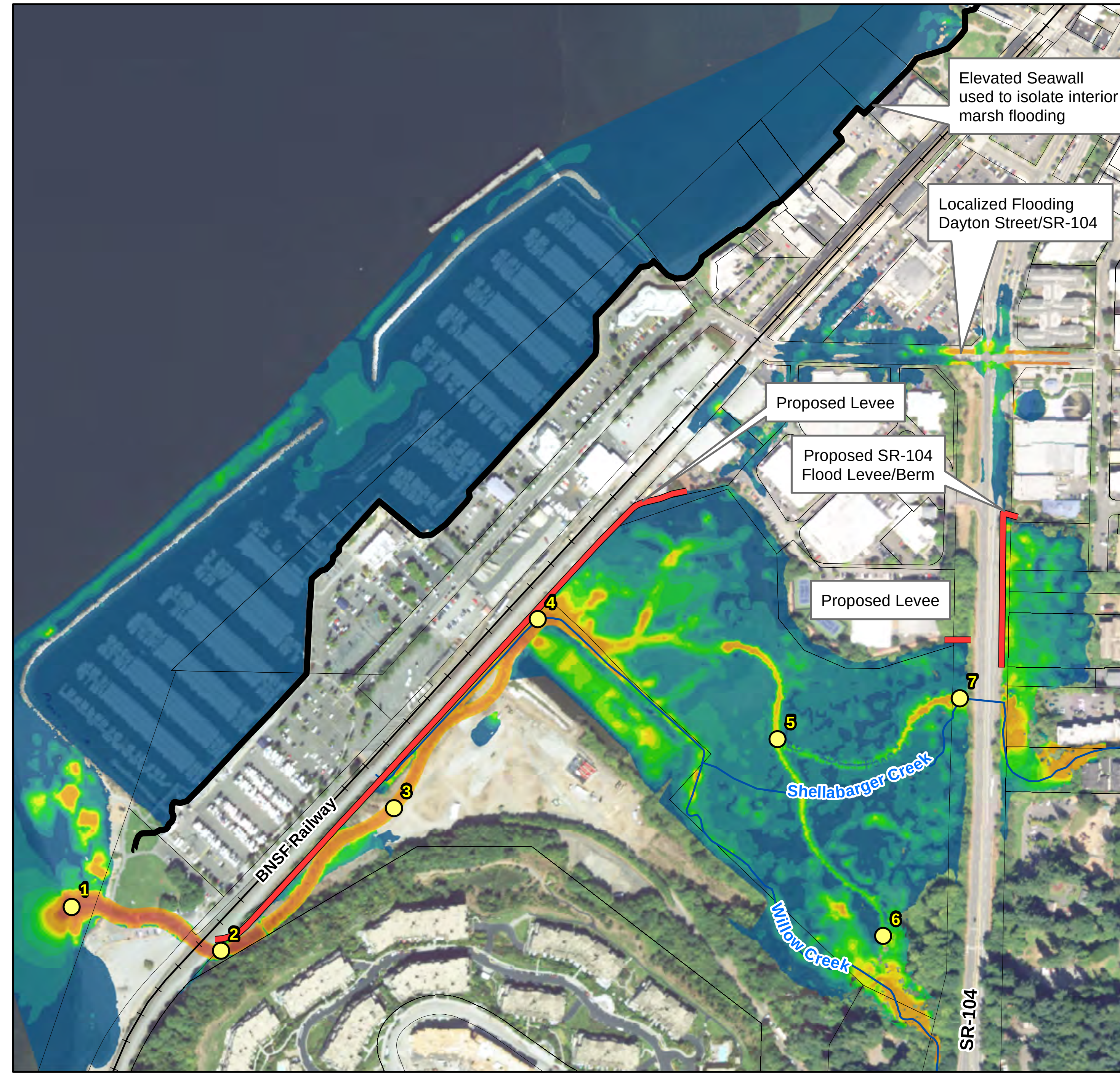
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 37A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure29A_Existing_Alternative6_KingTideSLR2100_SAIC_Depth.mxd Date: 12/20/2018 CCB



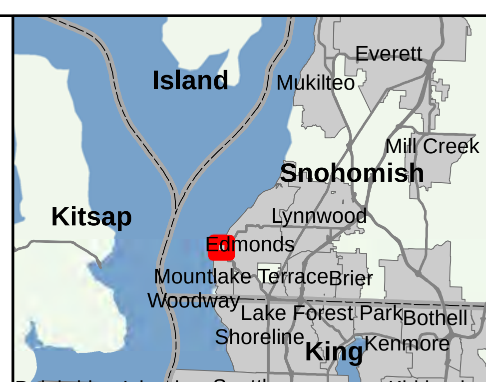
EXISTING CONDITIONS



ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S



EXISTING AND ALTERNATIVE 6 KING TIDE WITH SLR-2100 AND SAIC 1% (100-YR) AEP INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N W E S

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

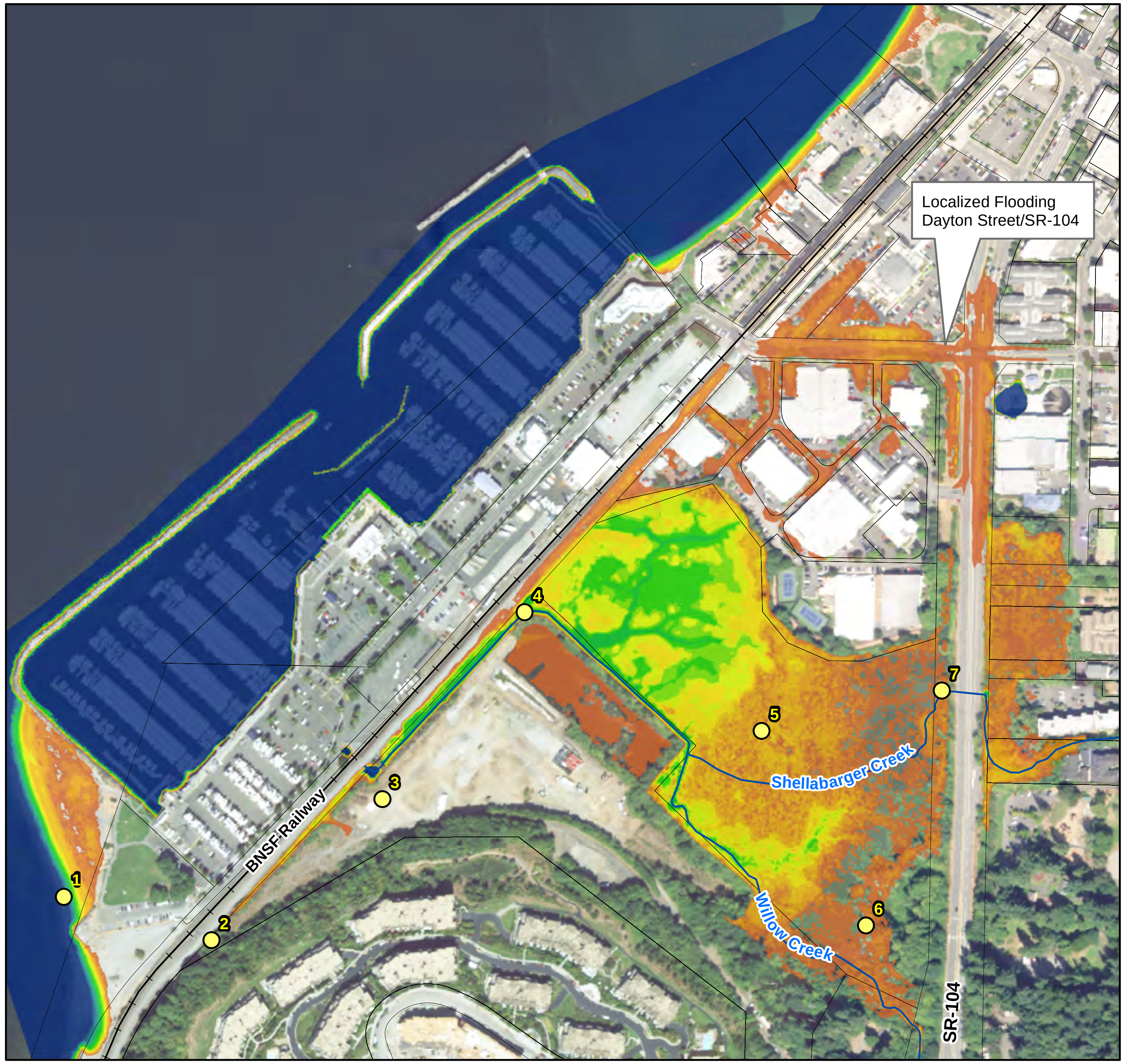
March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 37B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure29B_Existing_Alternative6_KingTideSLR2100_SAIC_Velocities.mxd Date: 12/20/2018 CCB

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure32A_Existing_Alternative6_StormSurge_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 6
STORM SURGE TIDE
AND 1% (100-YR) SAIC
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N
W E
S

0 450 900
Feet

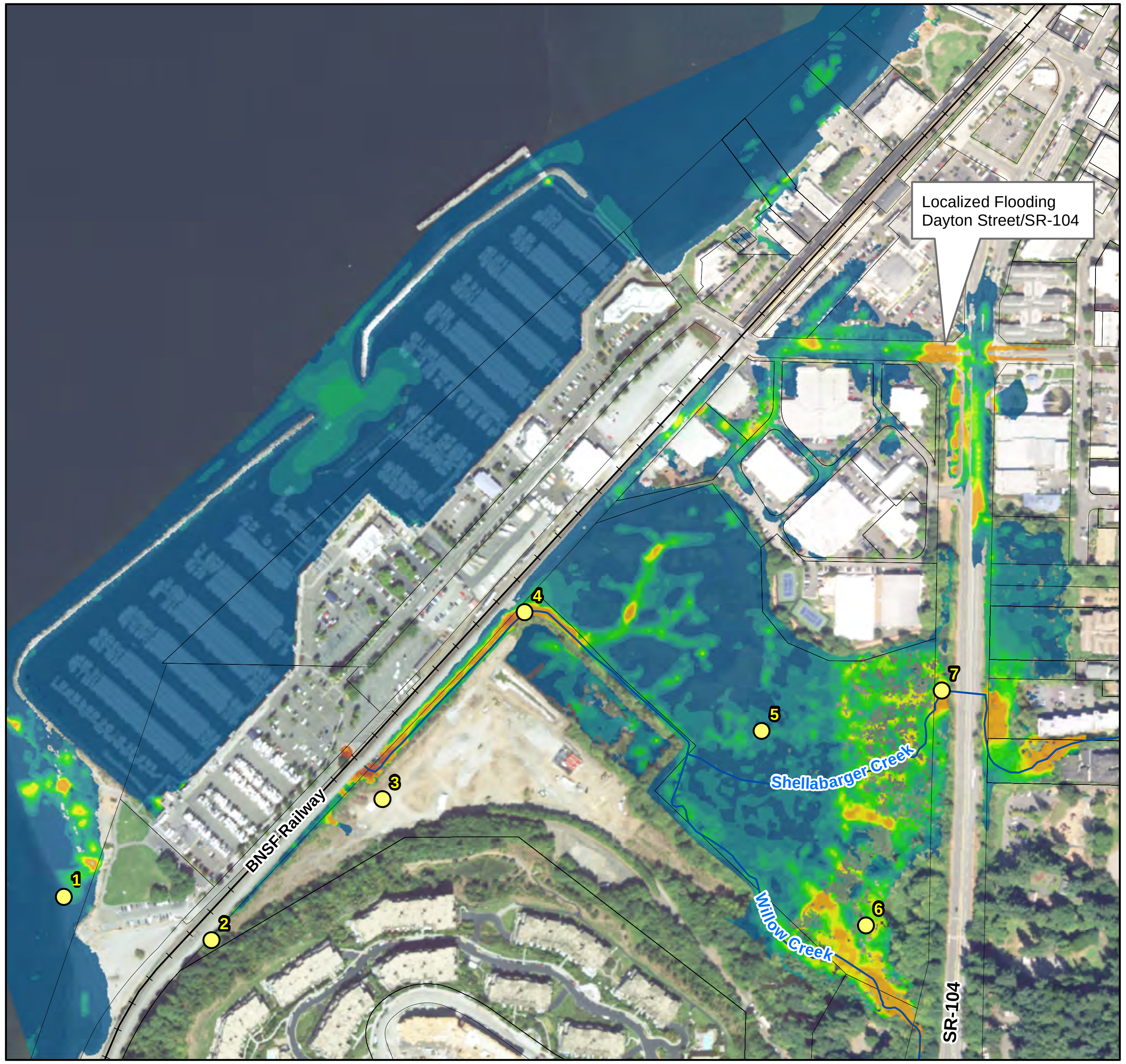
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 38A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure32B_Existing_Alternative6_StormSurge_SAIC_Velocities.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

**EXISTING AND ALTERNATIVE 6
STORM SURGE TIDE
AND SAIC 1% (100-YR)
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)**

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

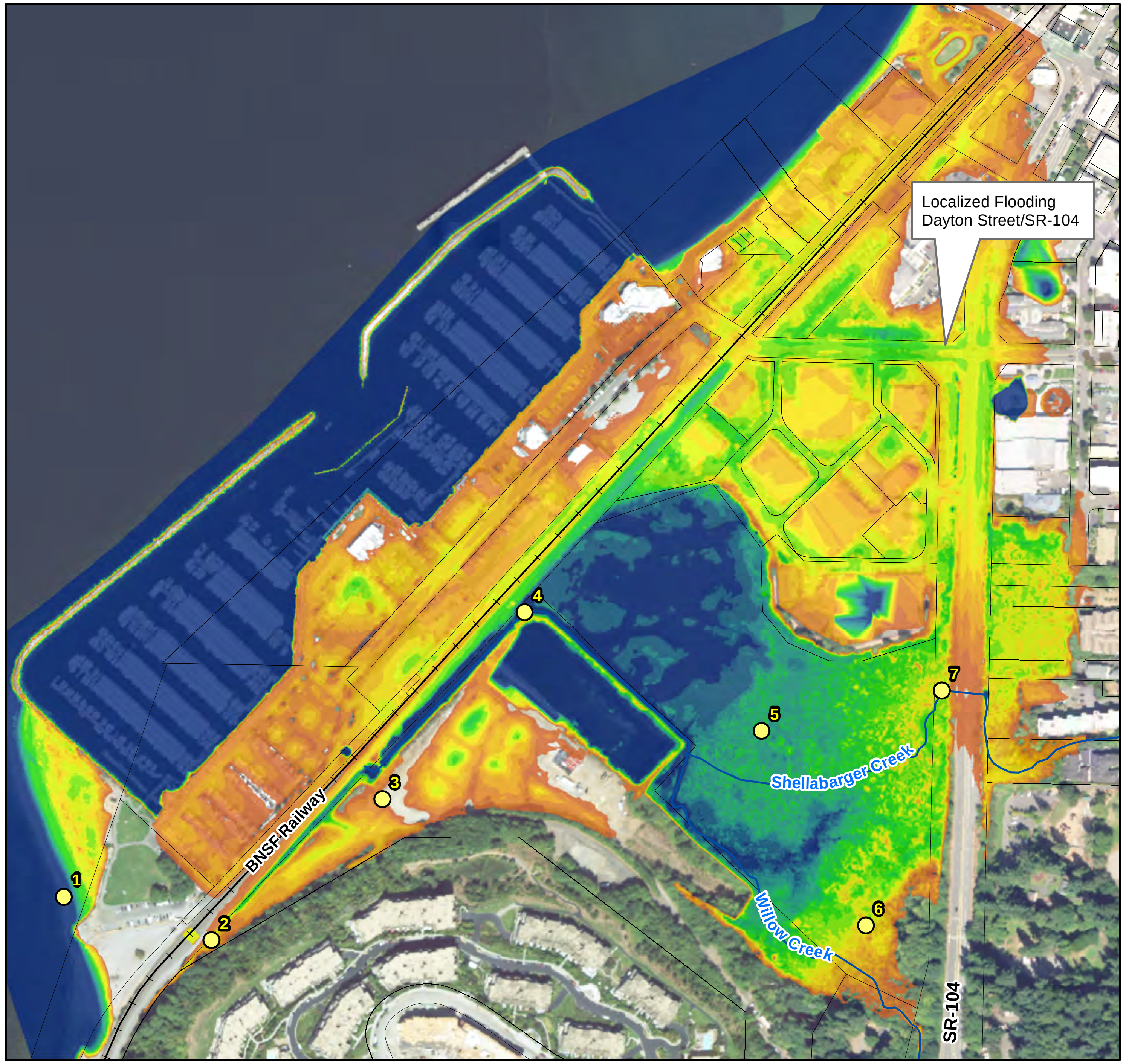
**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

March 2019 21-1-12588-050

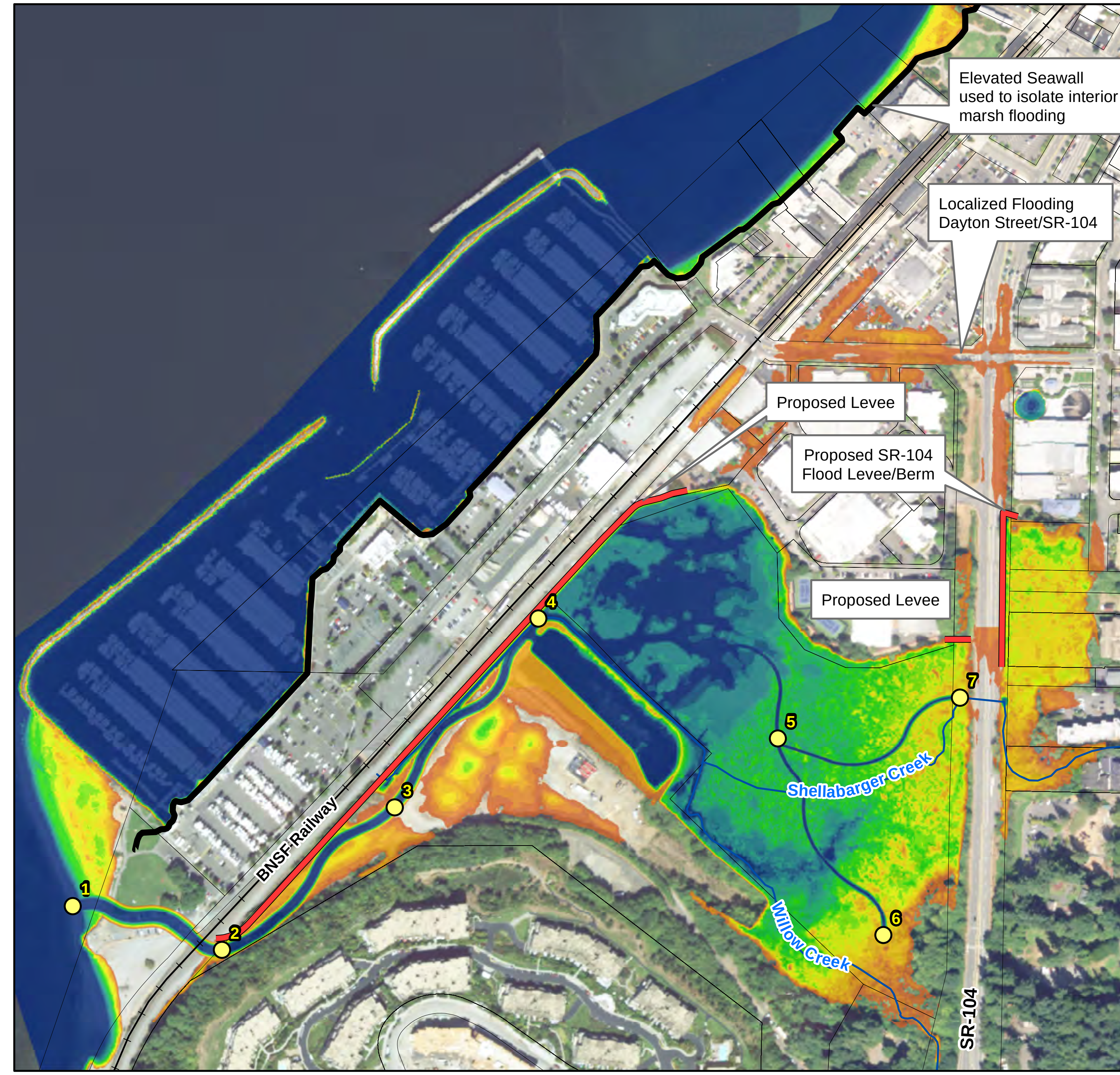
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 38B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure33A_Existing_Alternative6_StormSurgeSLR2100_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS



ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 6
STORM SURGE TIDE WITH SLR-2100
AND 1% (100-YR) SAIC
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N W E S

0 450 900
Feet

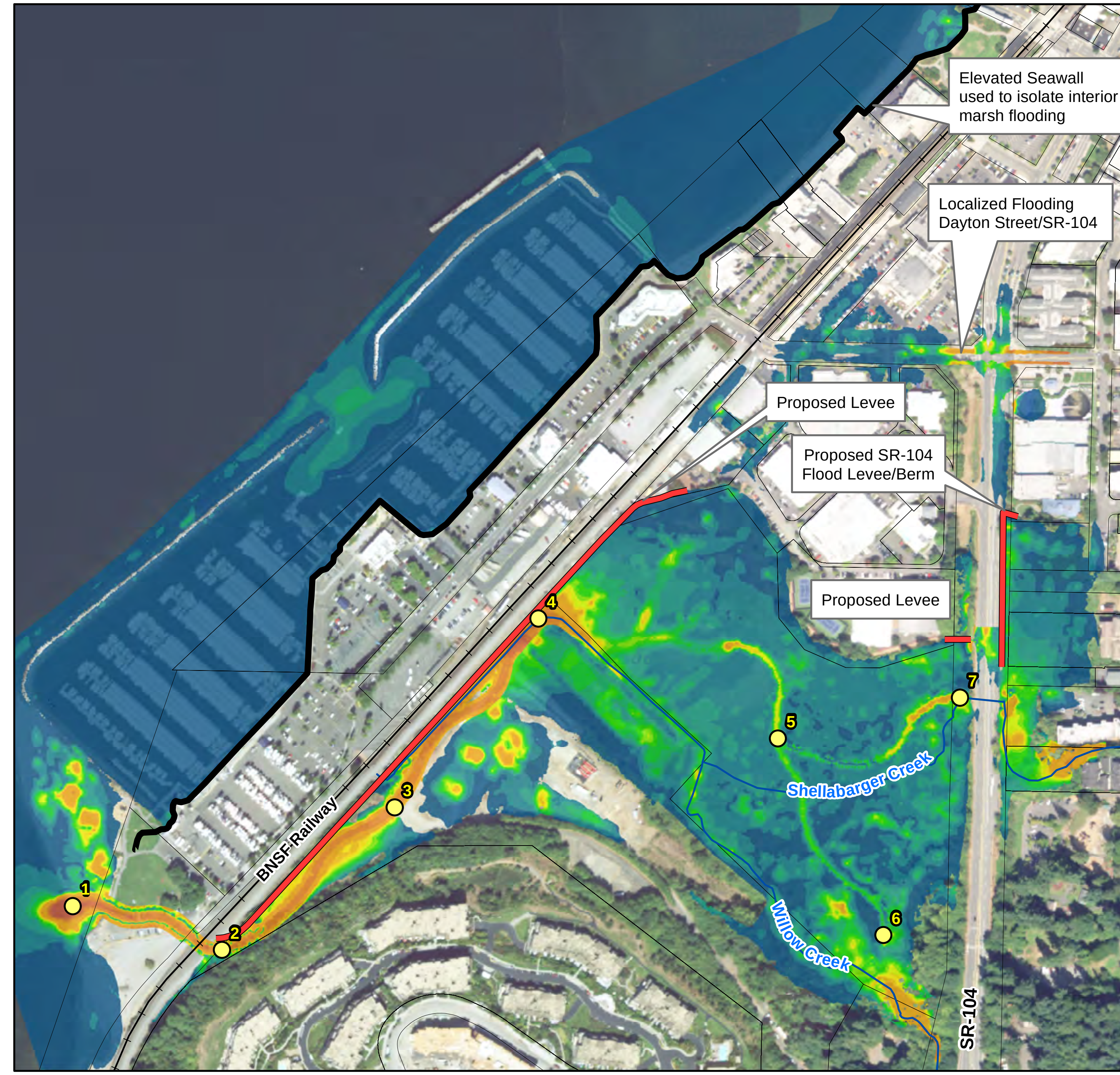
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 39A

EXISTING CONDITIONS



ALTERNATIVE 6
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION LEVEES/BERMS

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 6 STORM SURGE TIDE WITH SLR-2100 AND SAIC 1% (100-YR) INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N W E S

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

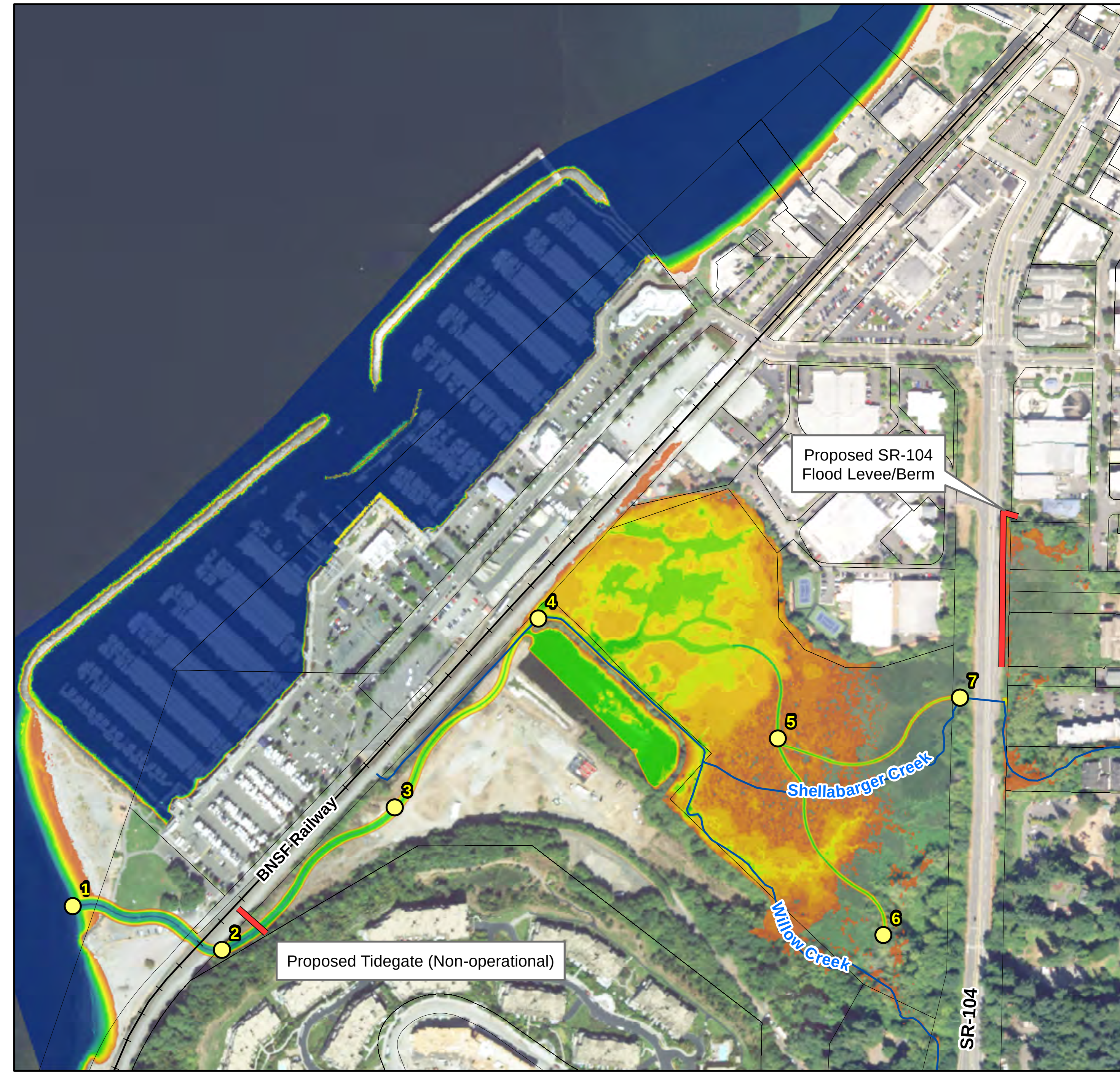
March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 39B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure33B_Existing_Alternative6_StormSurgeSLR2100_SAIC_Velocities.mxd Date: 12/20/2018 CCB

EXISTING CONDITIONS



ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 7 KING TIDE WITH LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N
W E
S

0 450 900
Feet

CITY OF EDMONDS
Est. 1890

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 40A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure36A_Existing_Alternative7_KingTide_Habitat_Depth.mxd Date: 12/20/2018 CCB

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure36B_Existing_Alternative7_KingTide_Habitat_Velocity.mxd Date: 12/20/2018 CCB

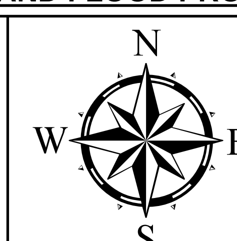
EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 7 KING TIDE WITH LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)



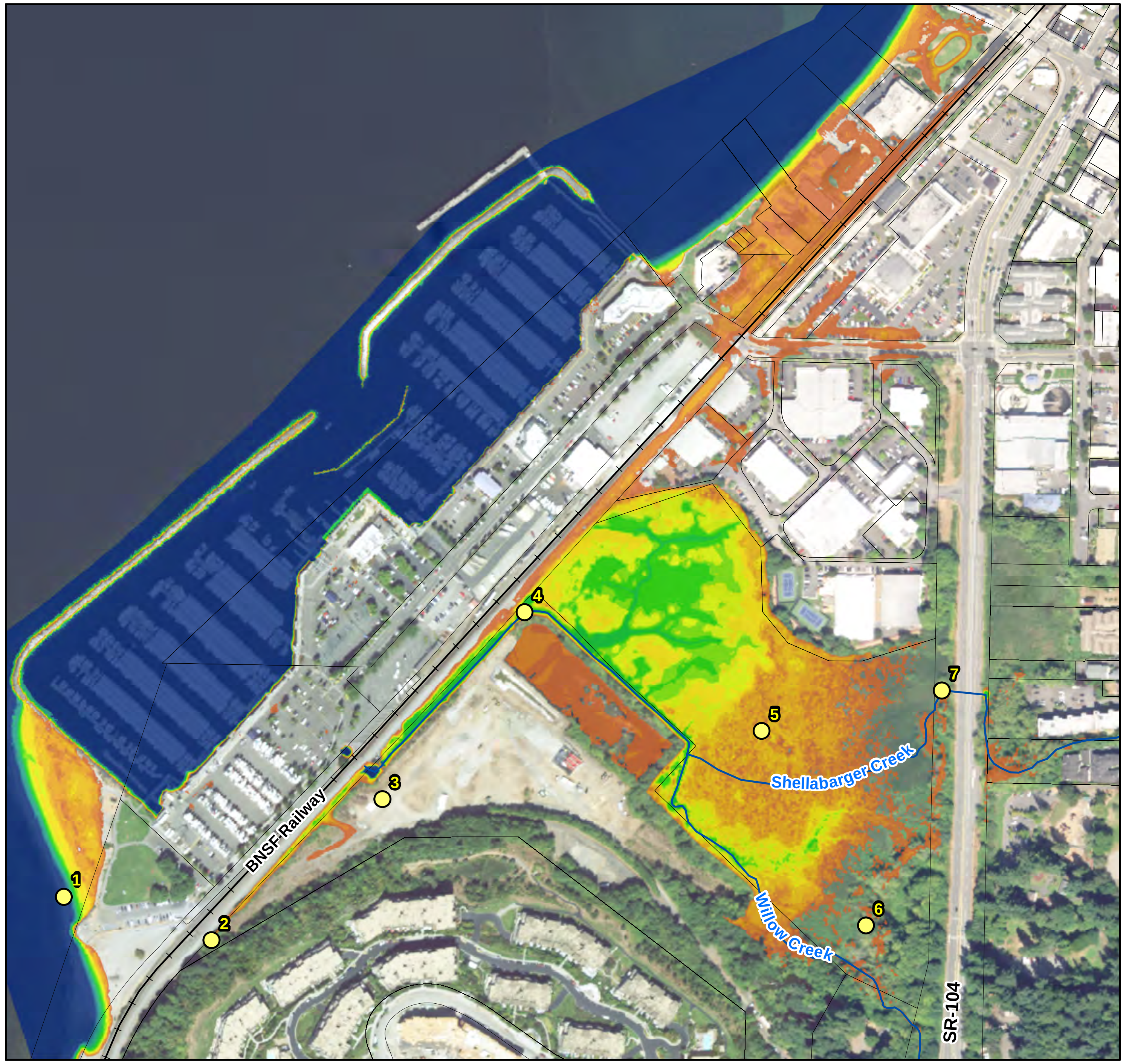
0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 40B



EXISTING CONDITIONS

ALTERNATIVE 7 MEANDERING DAYLIGHT CHANNEL WITH FISH HABITAT CHANNEL AND FLOOD PROTECTION BERMS AND TIDEGATE

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 7 KING TIDE WITH SLR-2100 AND LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM INUNDATION DEPTHS (FT)

N W E S

0 450 900
Feet

CITY OF EDMONDS Est. 1890

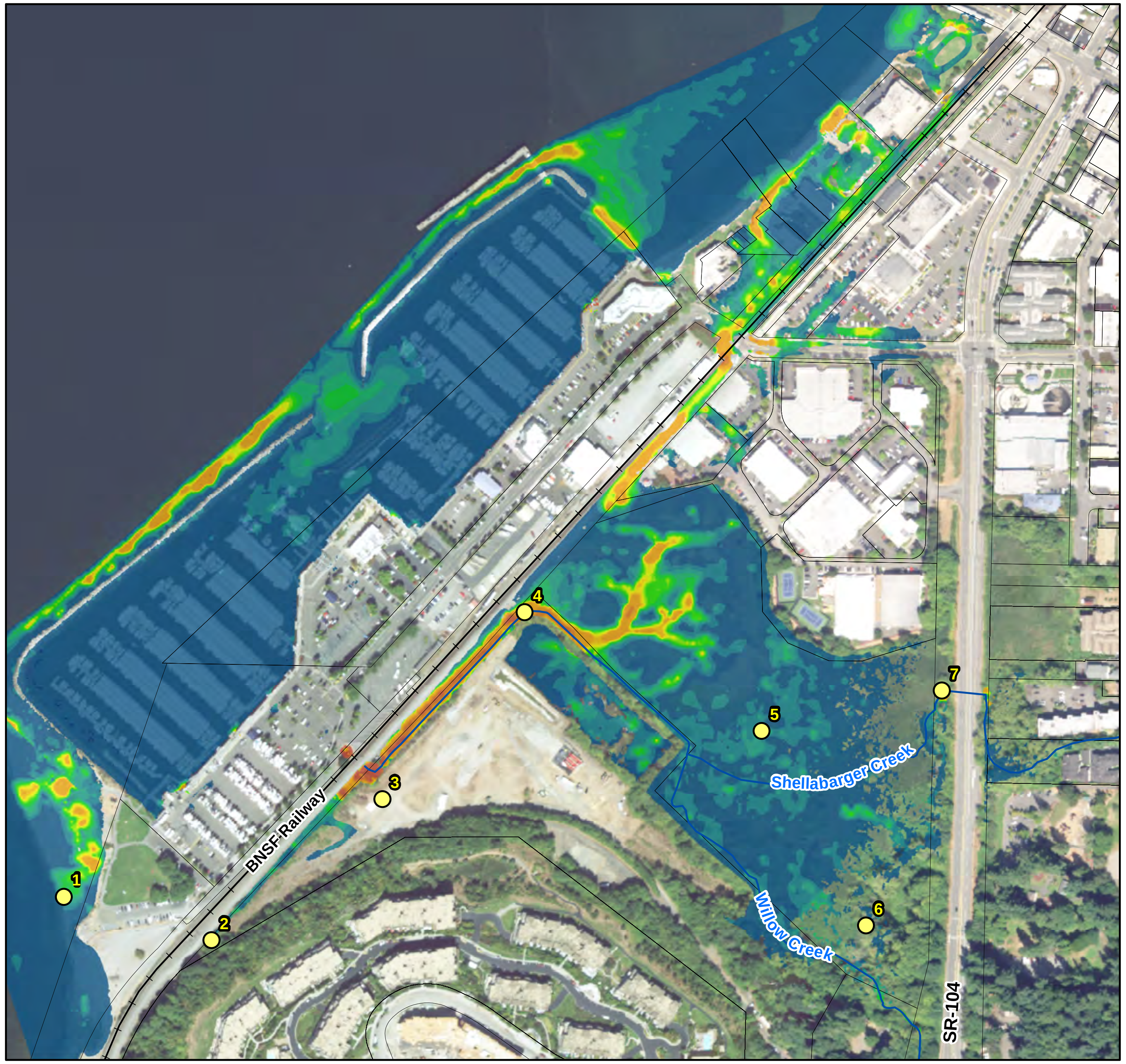
WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 41A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure37A_Existing_Alternative7_KingTideSLR2100_Habitat_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 7 KING TIDE WITH SLR-2100 AND LATE SPRING FISH HABITAT INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

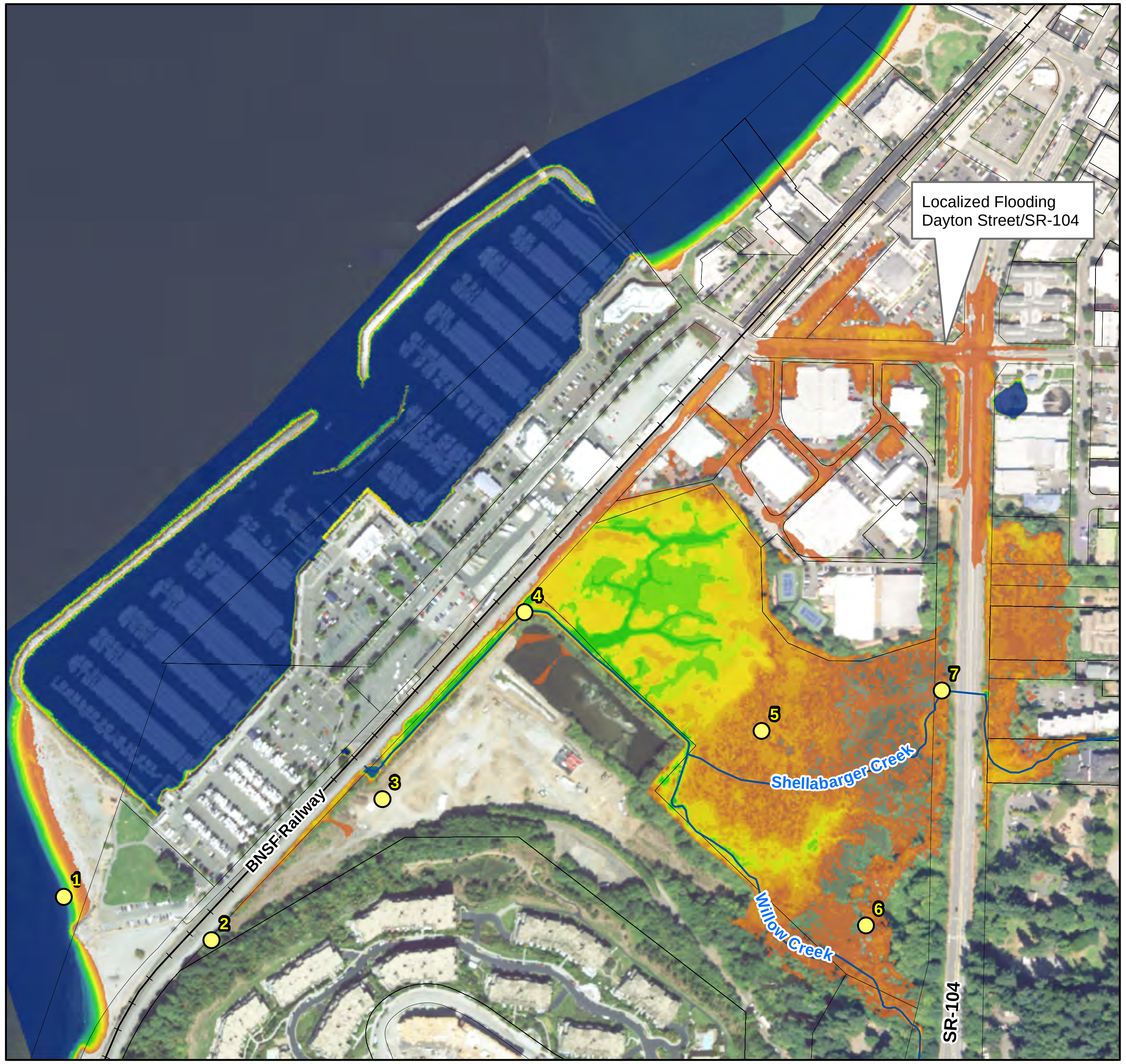
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 — 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 41B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure37B_Existing_Alternative7_KingTideSLR2100_Habitat_Velocity.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 7
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

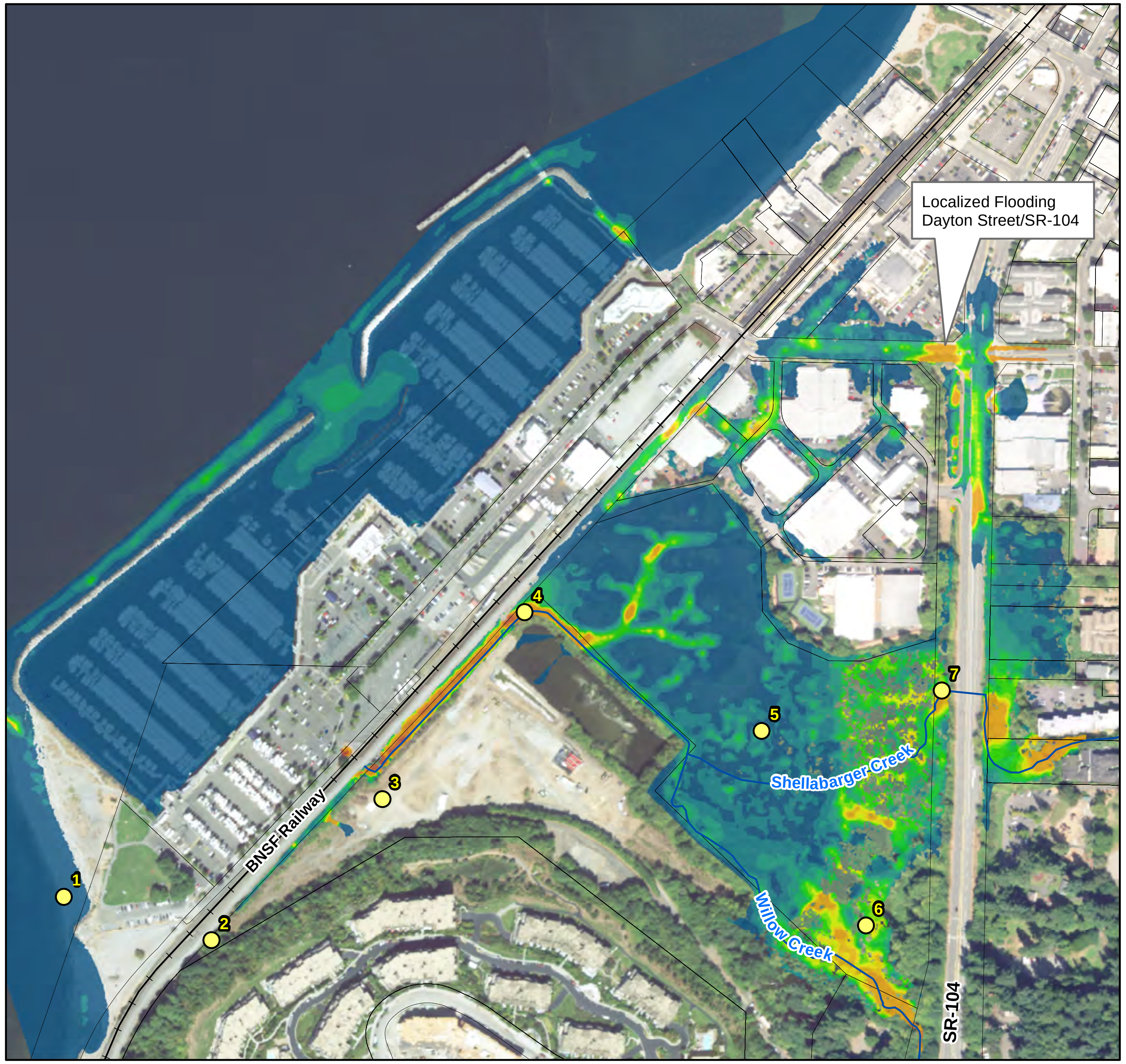
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 42A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure38A_Existing_Alternative7_KingTide_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Velocities

- 0.0 - 0.1 FT/S
- 0.1 - 0.2 FT/S
- 0.2 - 0.3 FT/S
- 0.3 - 0.4 FT/S
- 0.4 - 0.5 FT/S
- 0.5 - 0.6 FT/S
- 0.7 - 0.8 FT/S
- 0.8 - 0.9 FT/S
- 0.9 - 1.0 FT/S
- 1.0 - 2.0 FT/S
- 2.0 - 3.0 FT/S
- 3.0 - 4.0 FT/S
- 4.0 - 5.0 FT/S
- 5.0+ FT/S

EXISTING AND ALTERNATIVE 7
KING TIDE WITH SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

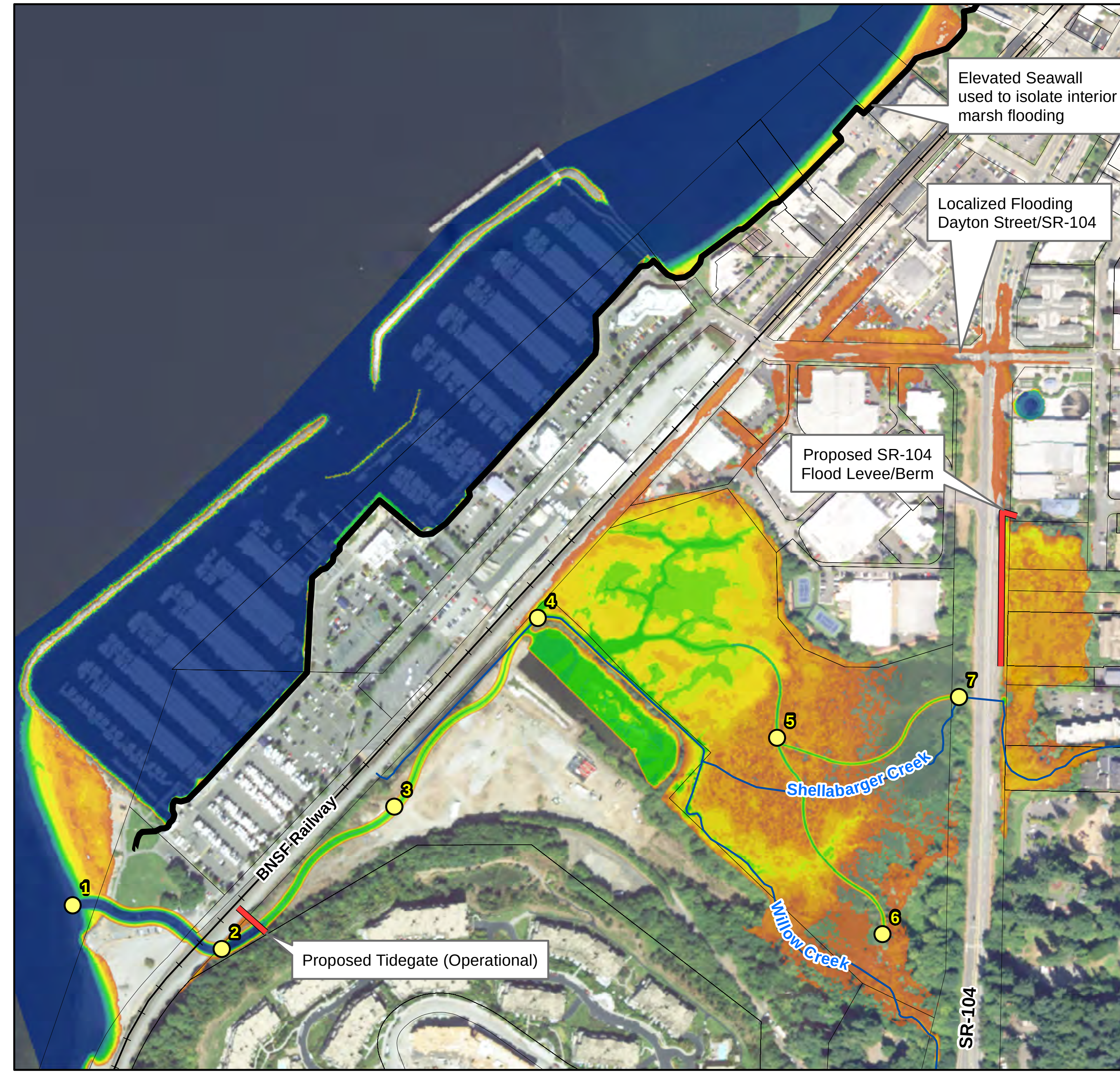
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 42B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure39A_Existing_Alternative7_KingTideSLR2100_SAIC_Depth.mxd Date: 12/20/2018 CCB

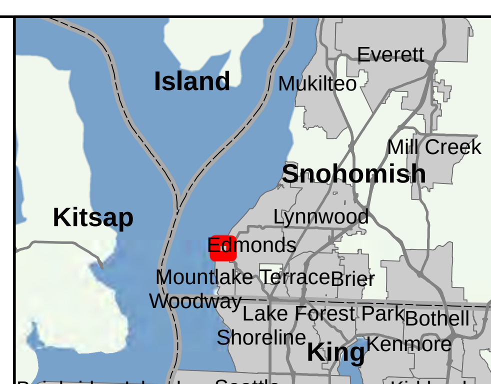


EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT



**EXISTING AND ALTERNATIVE 7
KING TIDE WITH SLR-2100 AND
SAIC 1% (100-YR) AEP
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)**

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

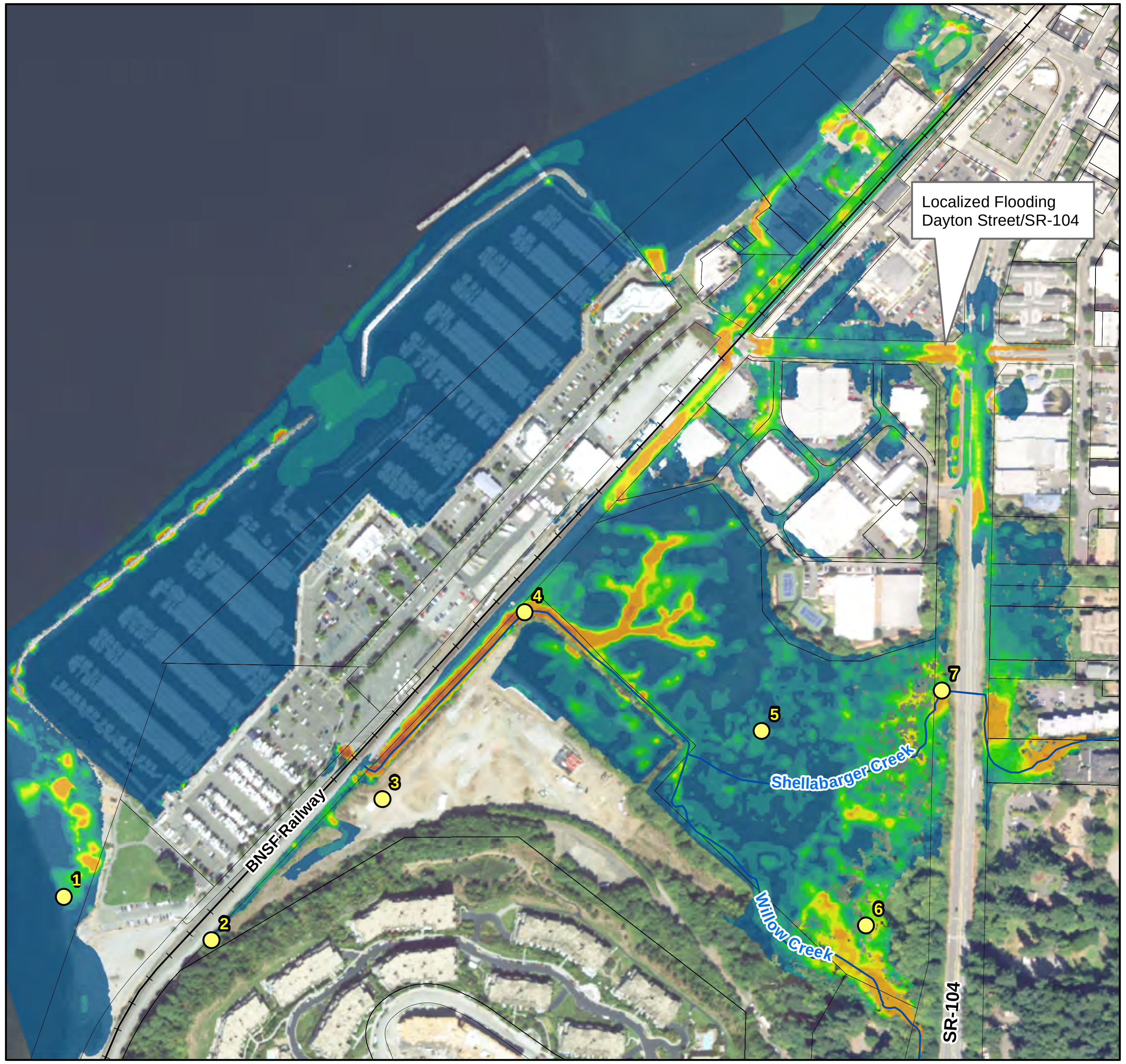
**WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON**

March 2019 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 43A

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure39B_Existing_Alternative7_KingTideSLR2100_SAIC_Velocities.mxd Date: 12/20/2018 CCB



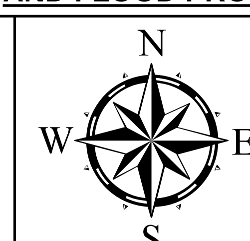
EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 7 KING TIDE WITH SLR-2100 AND SAIC 1% (100-YR) AEP INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)



CITY OF EDMONDS Est. 1890

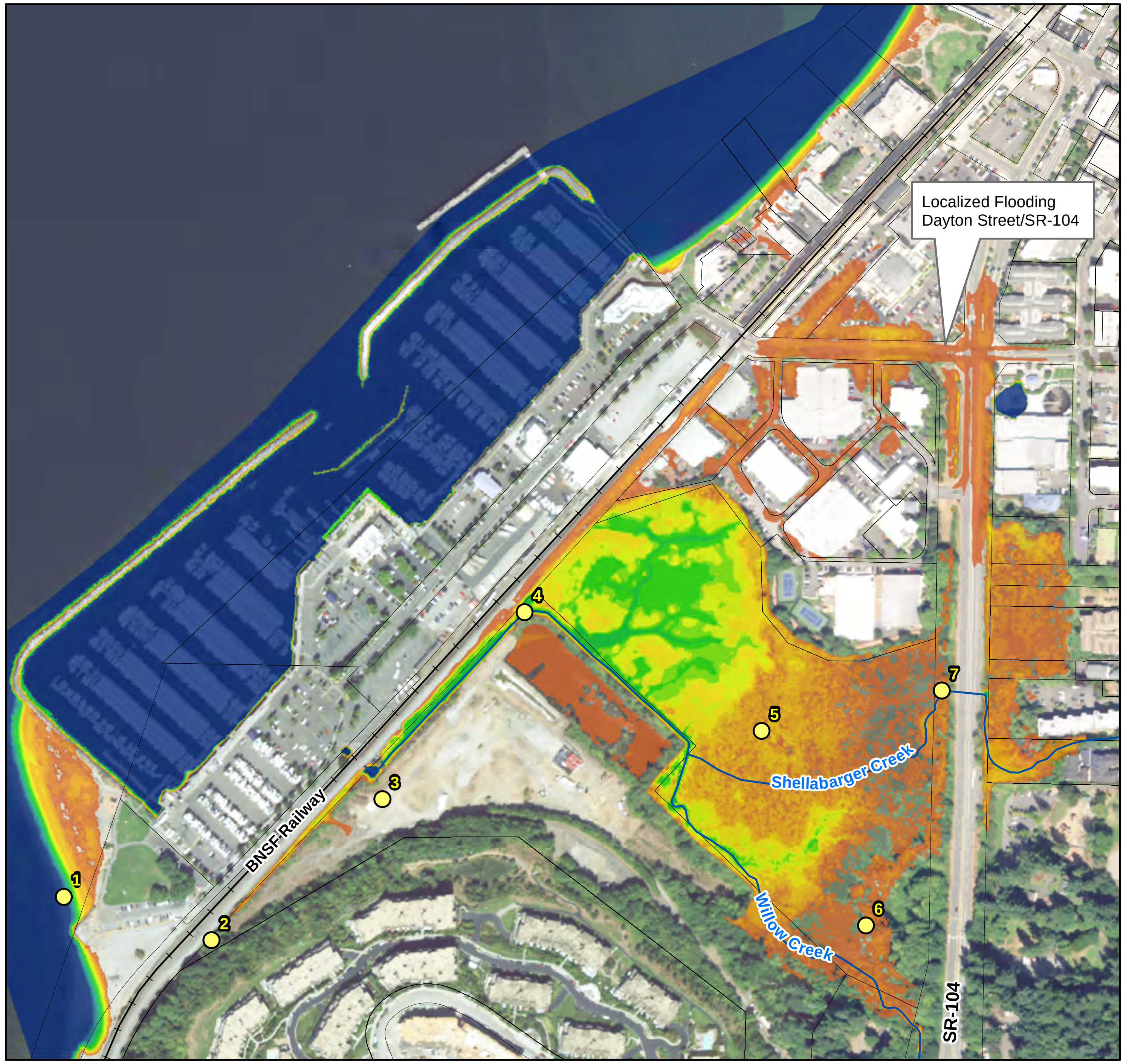
0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

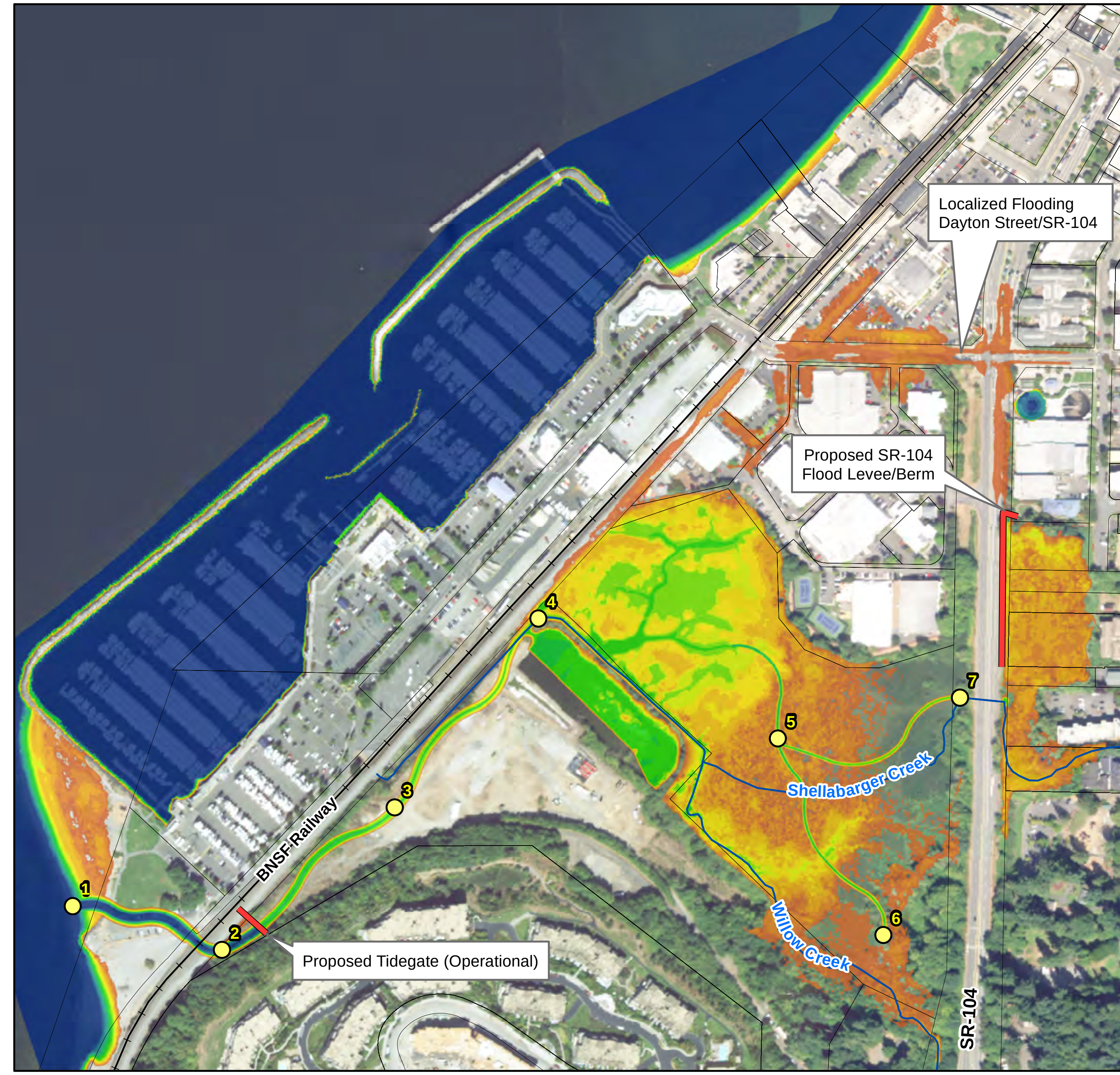
March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 43B



EXISTING CONDITIONS



ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 7
STORM SURGE TIDE
AND SAIC 1% (100-YR)
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N
W E
S

CITY OF EDMONDS
Est. 1890

0 450 900
Feet

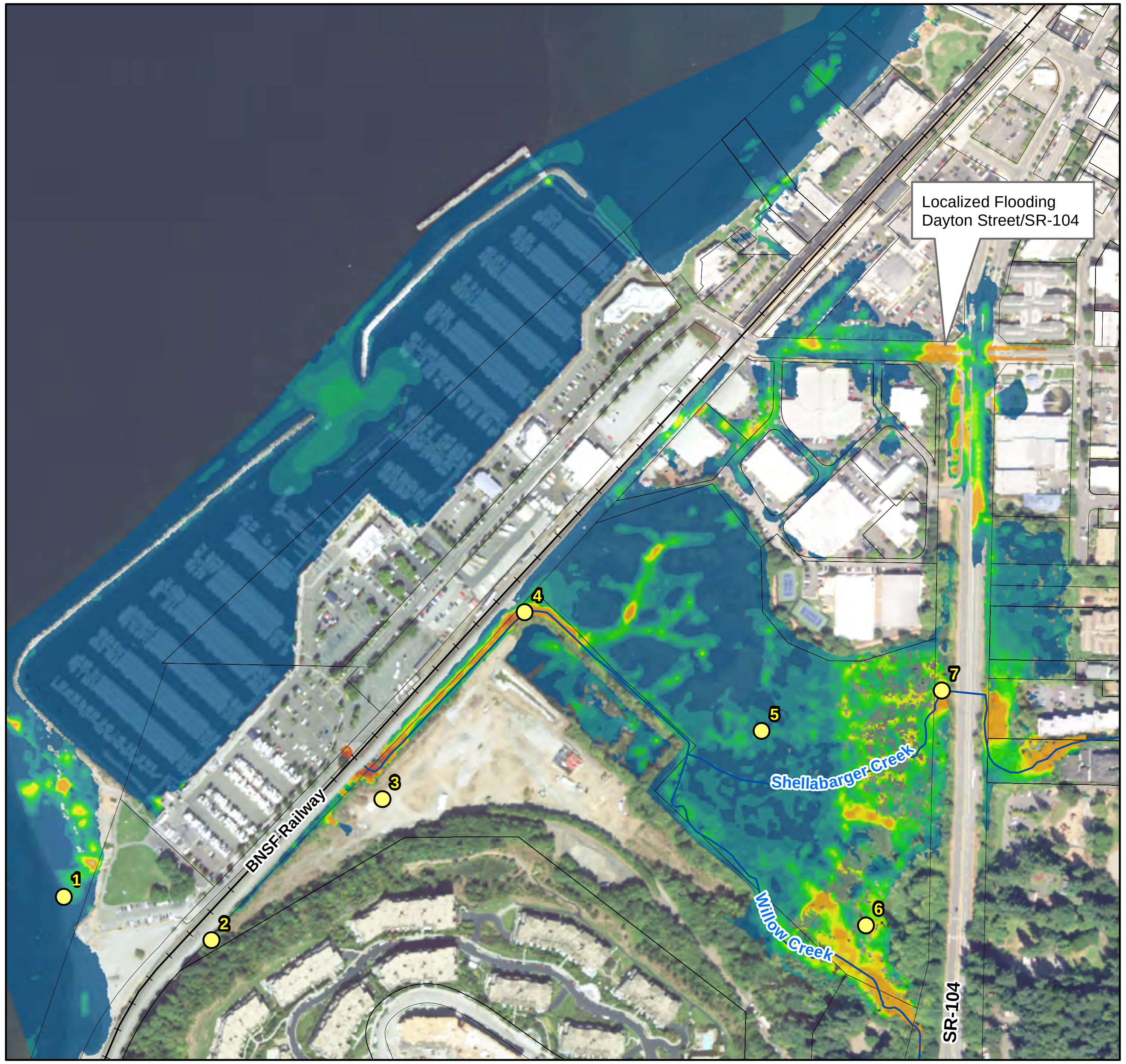
WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 44A

Filename: I:\EFR\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Report\Figures\MXD\Figure42A_Existing_Alternative7_StormSurge_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS

ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Velocities

0.0 - 0.1 FT/S	0.8 - 0.9 FT/S
0.1 - 0.2 FT/S	0.9 - 1.0 FT/S
0.2 - 0.3 FT/S	1.0 - 2.0 FT/S
0.3 - 0.4 FT/S	2.0 - 3.0 FT/S
0.4 - 0.5 FT/S	3.0 - 4.0 FT/S
0.5 - 0.6 FT/S	4.0 - 5.0 FT/S
0.7 - 0.8 FT/S	5.0+ FT/S

EXISTING AND ALTERNATIVE 7
STORM SURGE TIDE
AND SAIC 1% (100-YR)
INFLOW HYDROGRAPHS
MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

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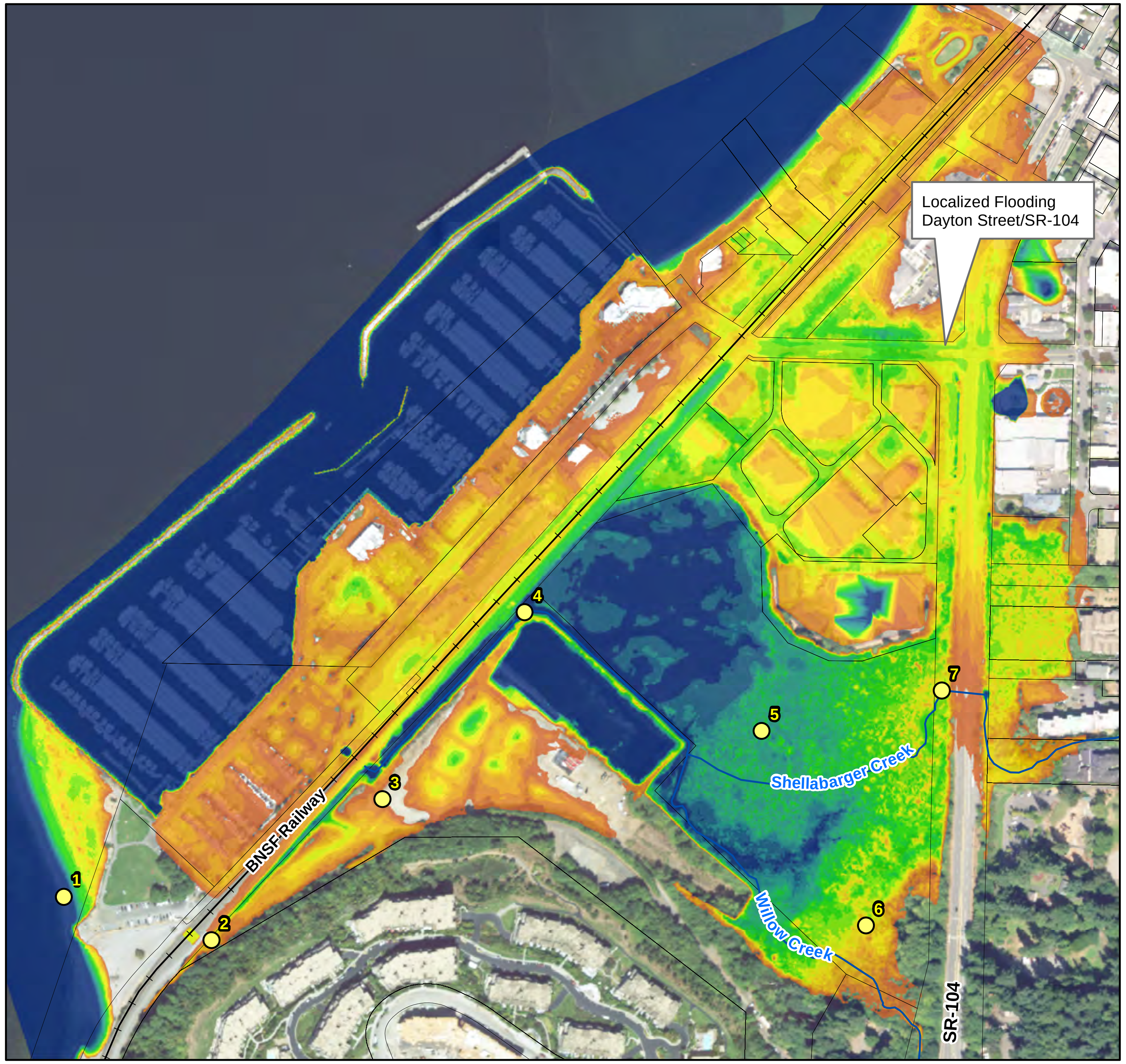
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

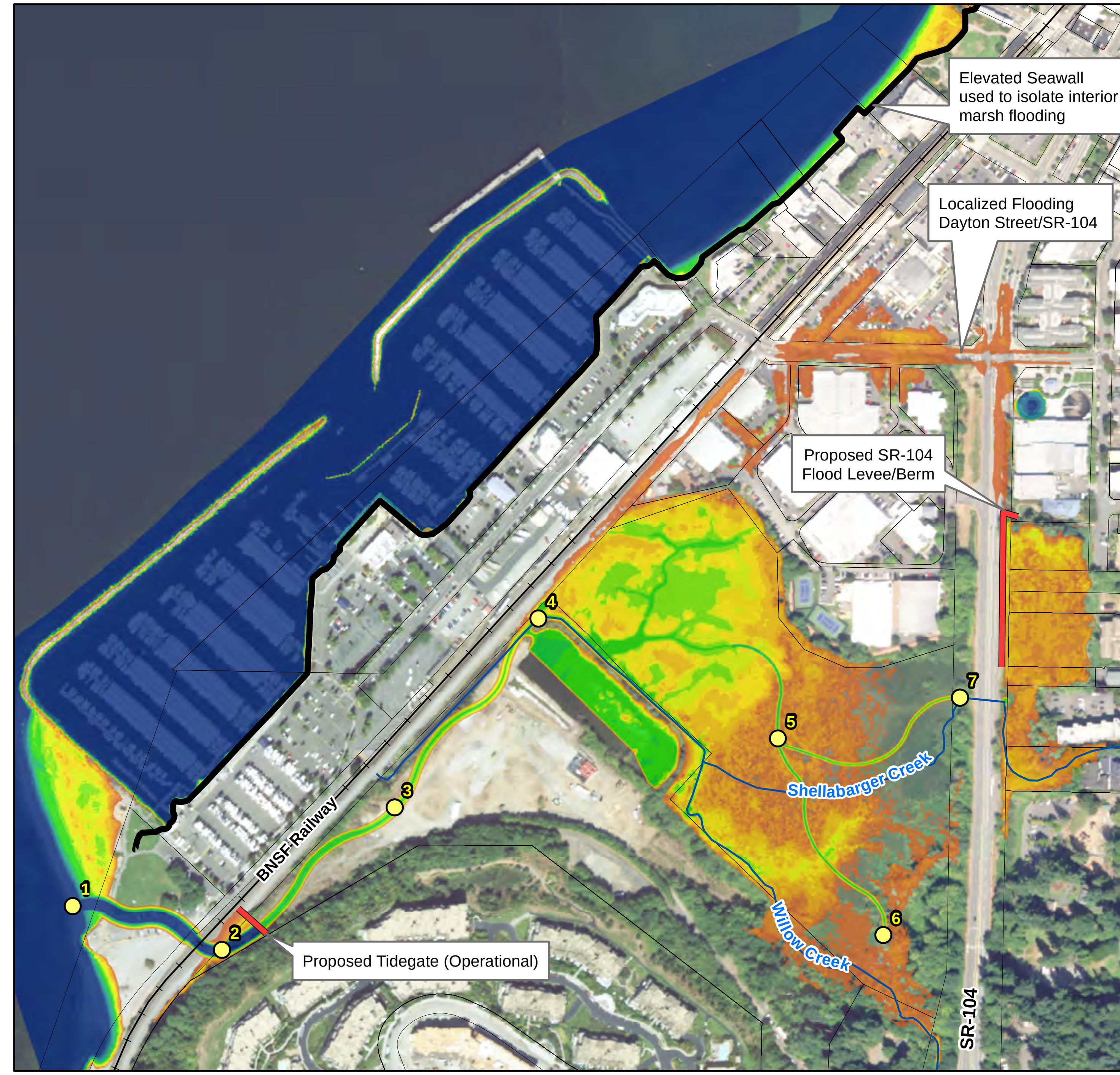
FIG. 44B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure42B_Existing_Alternative7_StormSurge_SAIC_Velocities.mxd Date: 12/20/2018 CCB

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure43A_Existing_Alternative7_StormSurgeSLR2100_SAIC_Depth.mxd Date: 12/20/2018 CCB



EXISTING CONDITIONS



ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Inundation Depths

0 - 0.5 FT	3.5 - 4 FT
0.5 - 1 FT	4 - 4.5 FT
1 - 1.5 FT	4.5 - 5 FT
1.5 - 2 FT	5 - 5.5 FT
2 - 2.5 FT	5.5 - 6 FT
2.5 - 3 FT	6 - 6.5 FT
3 - 3.5 FT	6.5+ FT

EXISTING AND ALTERNATIVE 7
STORM SURGE TIDE WITH SLR-2100
AND SAIC 1% (100-YR)
INFLOW HYDROGRAPHS
MAXIMUM INUNDATION DEPTHS (FT)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT
DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

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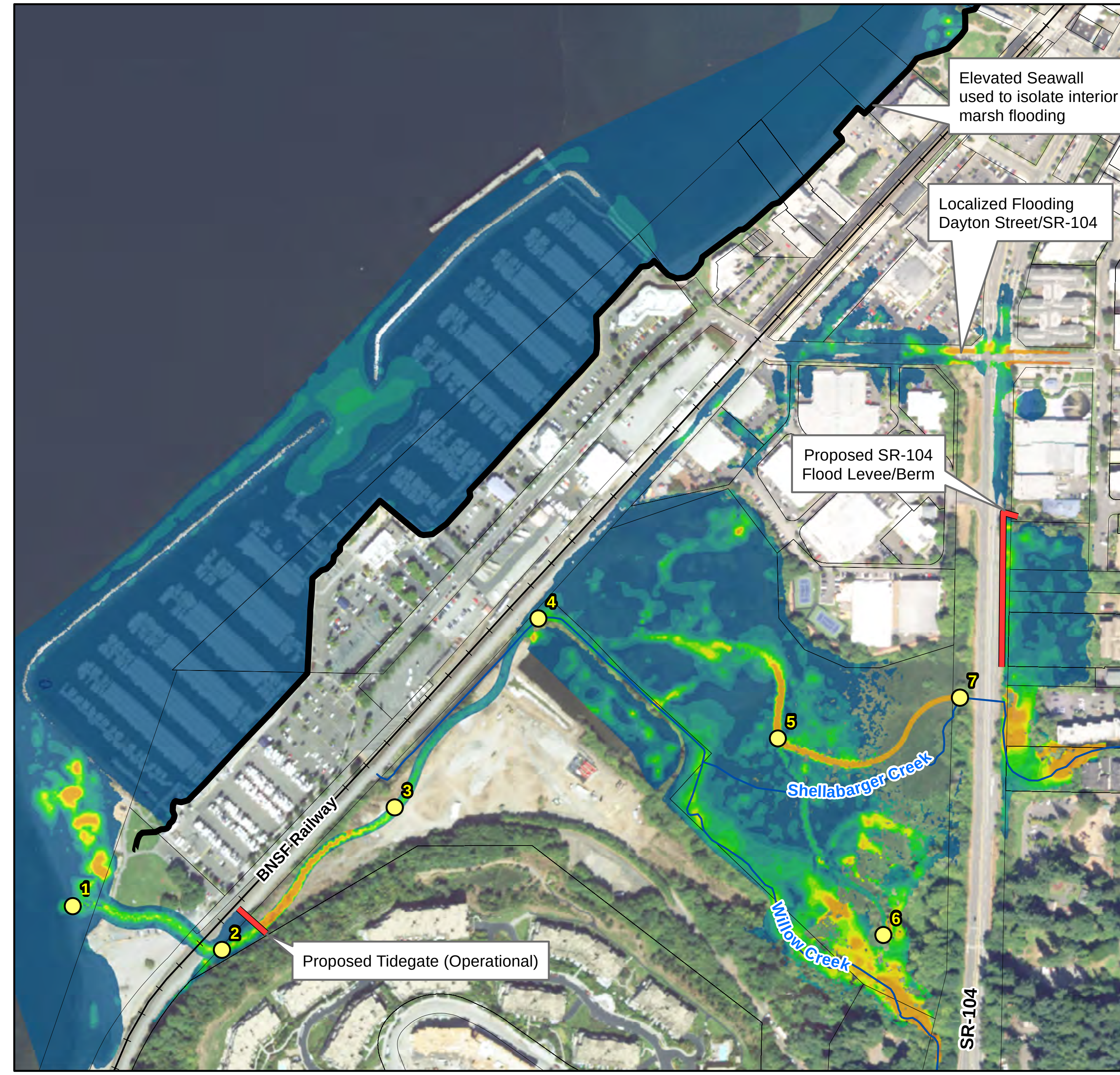
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 45A

EXISTING CONDITIONS



ALTERNATIVE 7
MEANDERING DAYLIGHT CHANNEL
WITH FISH HABITAT CHANNEL
AND FLOOD PROTECTION BERMS AND TIDEGATE

Velocities

- 0.0 - 0.1 FT/S
- 0.1 - 0.2 FT/S
- 0.2 - 0.3 FT/S
- 0.3 - 0.4 FT/S
- 0.4 - 0.5 FT/S
- 0.5 - 0.6 FT/S
- 0.7 - 0.8 FT/S
- 0.8 - 0.9 FT/S
- 0.9 - 1.0 FT/S
- 1.0 - 2.0 FT/S
- 2.0 - 3.0 FT/S
- 3.0 - 4.0 FT/S
- 4.0 - 5.0 FT/S
- 5.0+ FT/S

EXISTING AND ALTERNATIVE 7 STORM SURGE TIDE WITH SLR-2100 AND SAIC 1% (100-YR) INFLOW HYDROGRAPHS MAXIMUM VELOCITIES (FT/S)

N W E S

CITY OF EDMONDS Est. 1890

0 450 900
Feet

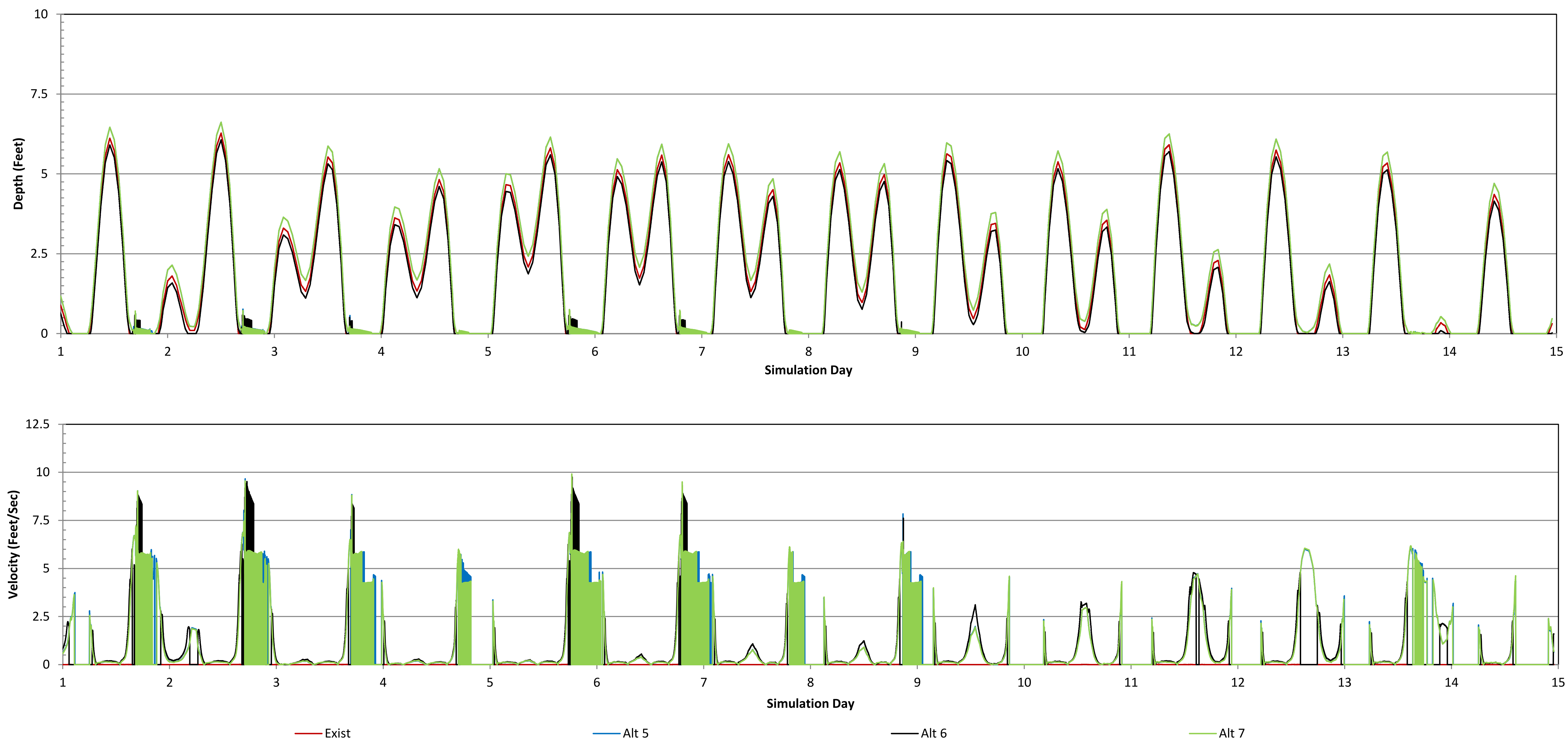
WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WASHINGTON

March 2019 | 21-1-12588-050

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 45B

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\ReportFigures\MXD\Figure43B_Existing_Alternative7_StormSurgeSLR2100_SAIC_Velocities.mxd Date: 12/20/2018 CCB



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 1 - OUTLET OF DAYLIGHT CHANNEL

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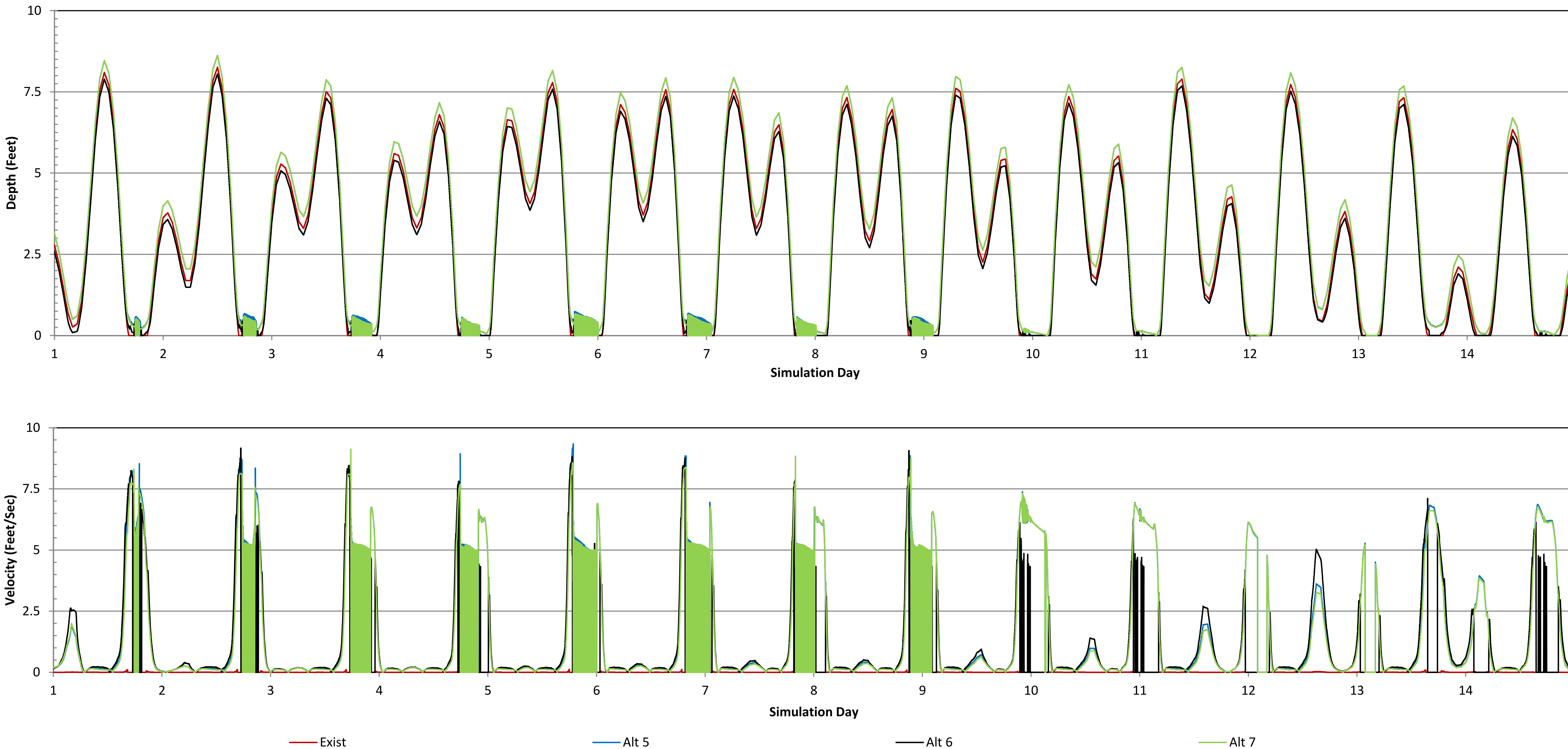
FIG. 46



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES
NODE 1 - OUTLET OF DAYLIGHT CHANNEL

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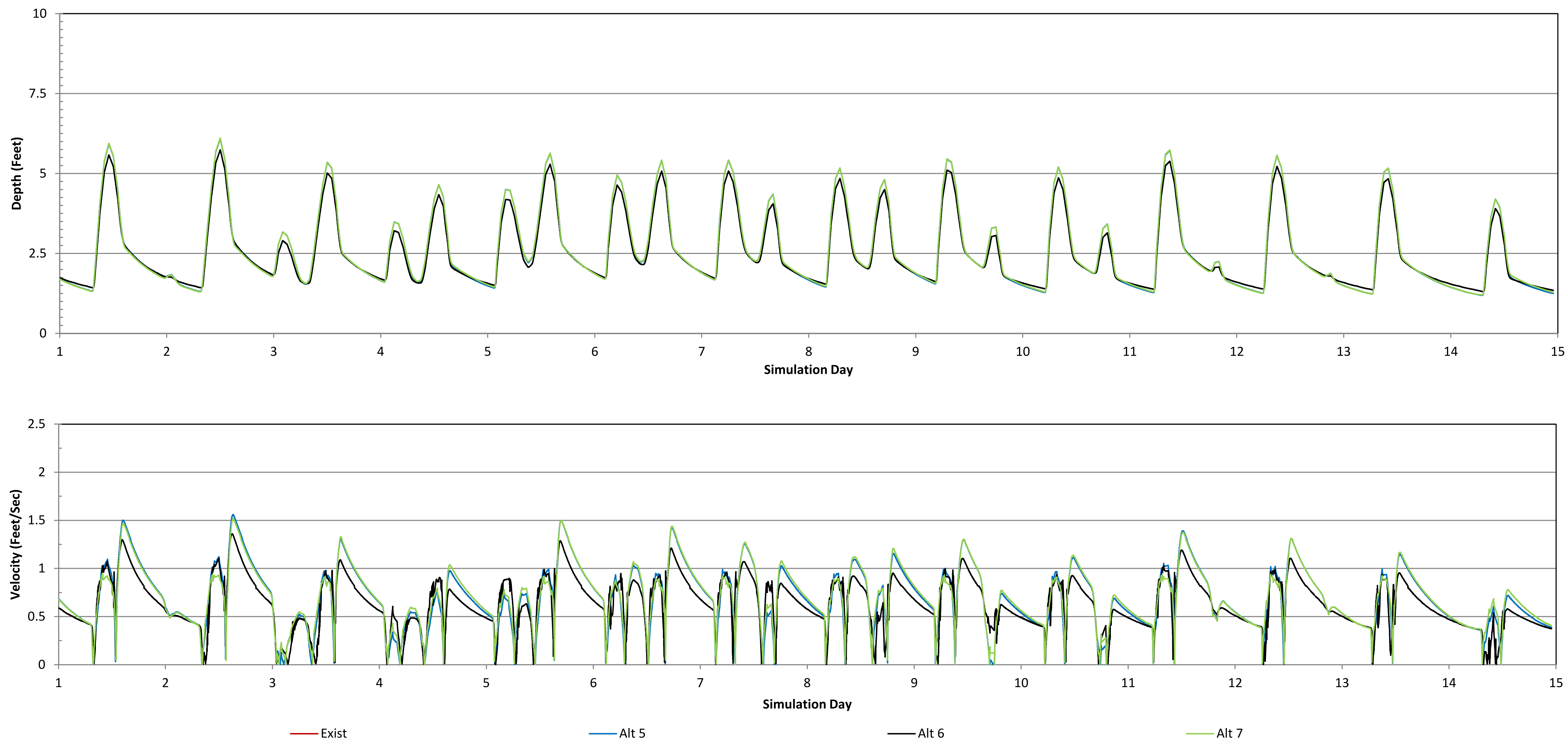
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 47



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 2 - UPSTREAM OF BNSF BRIDGE

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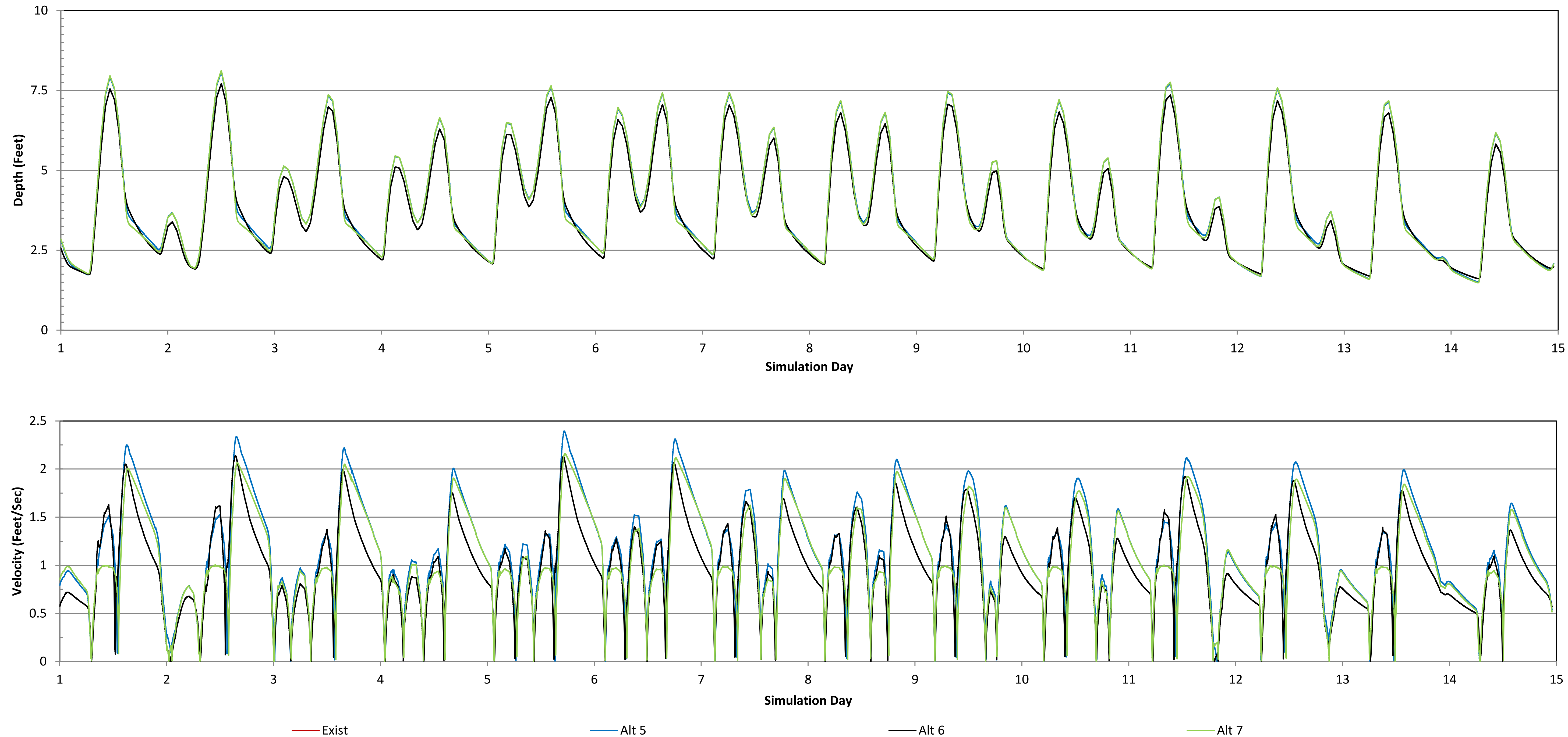
FIG. 48



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES
NODE 2 - UPSTREAM OF BNSF BRIDGE

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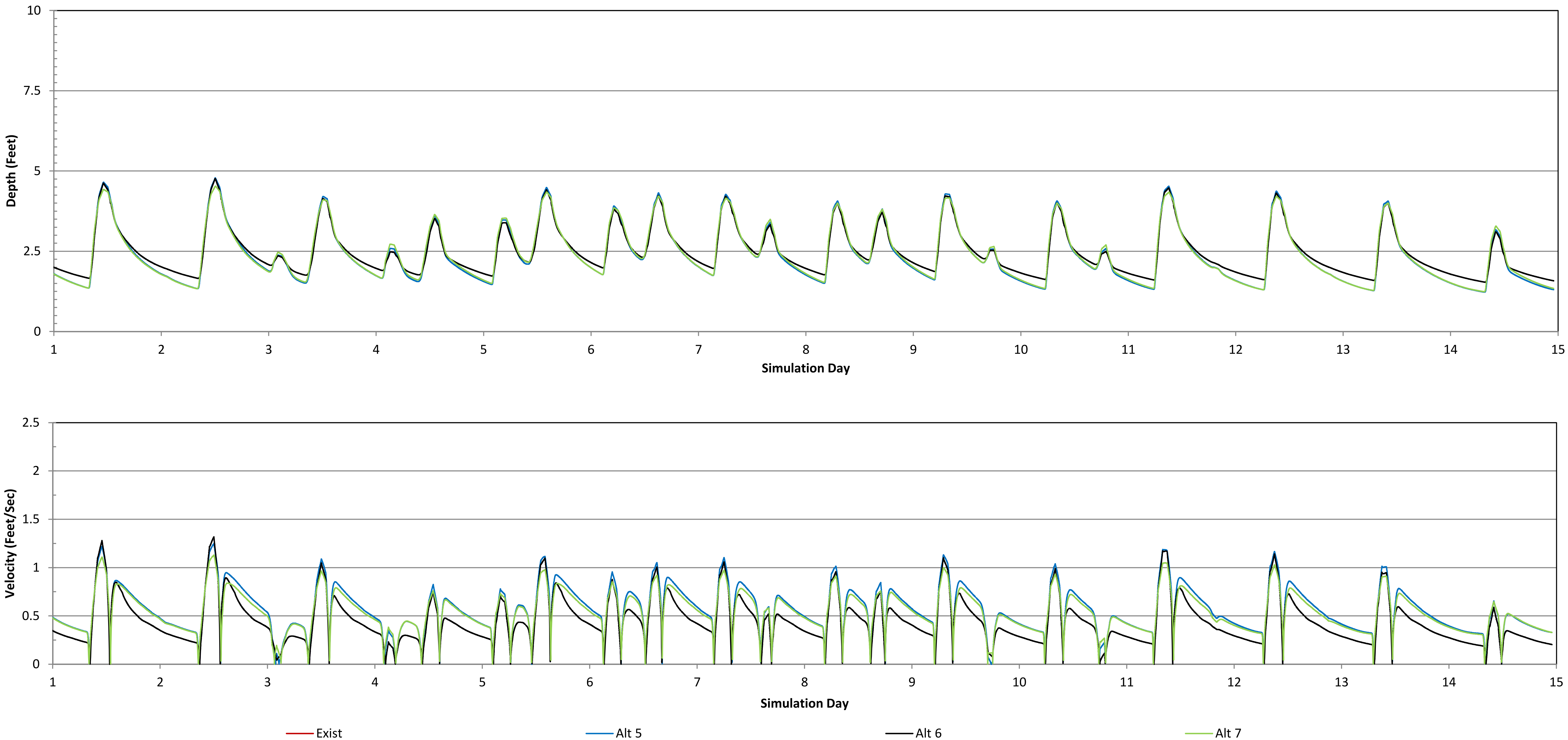
FIG. 49



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 3 - UPSTREAM OF BNSF BRIDGE

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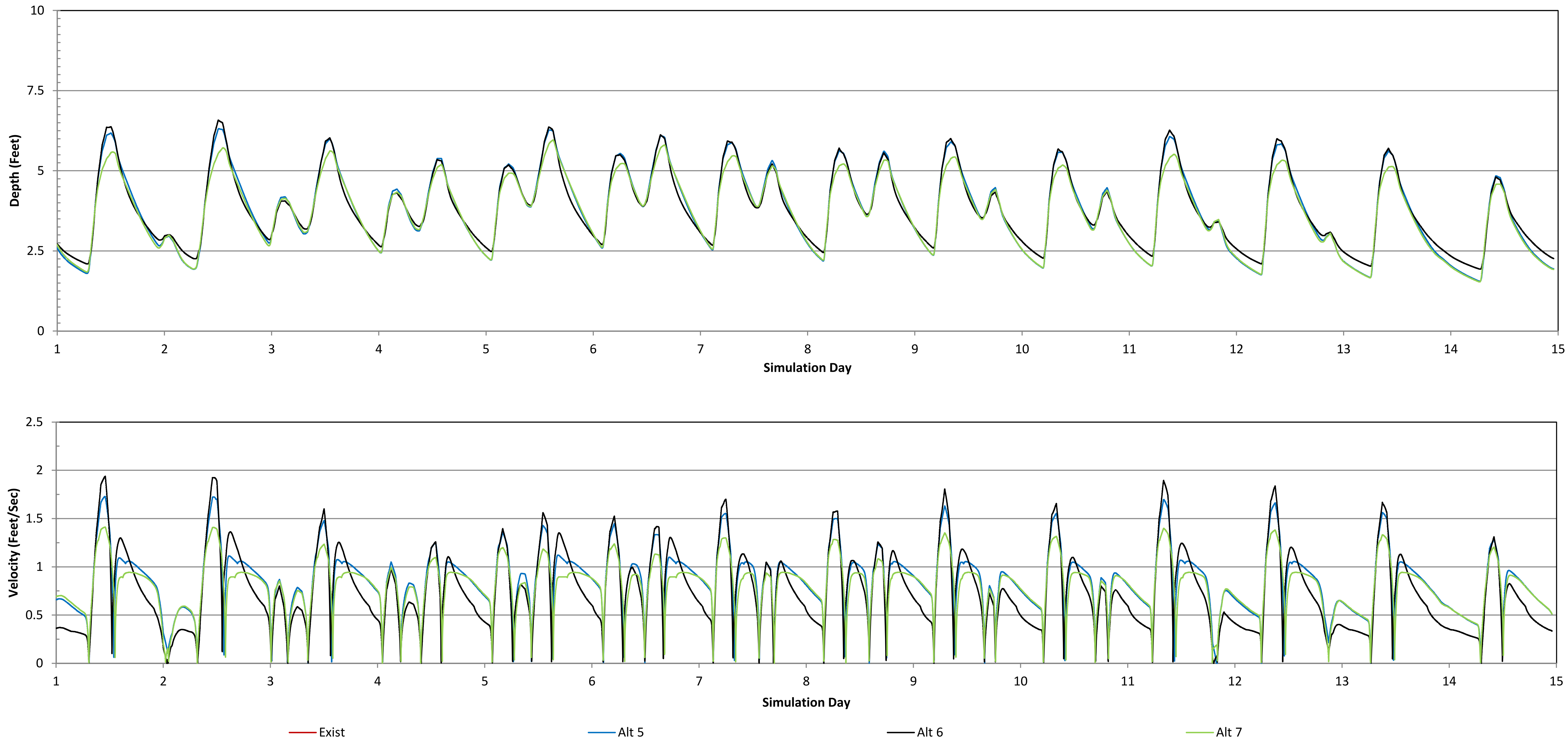
FIG. 50



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES
NODE 3 - UPSTREAM OF BNSF BRIDGE

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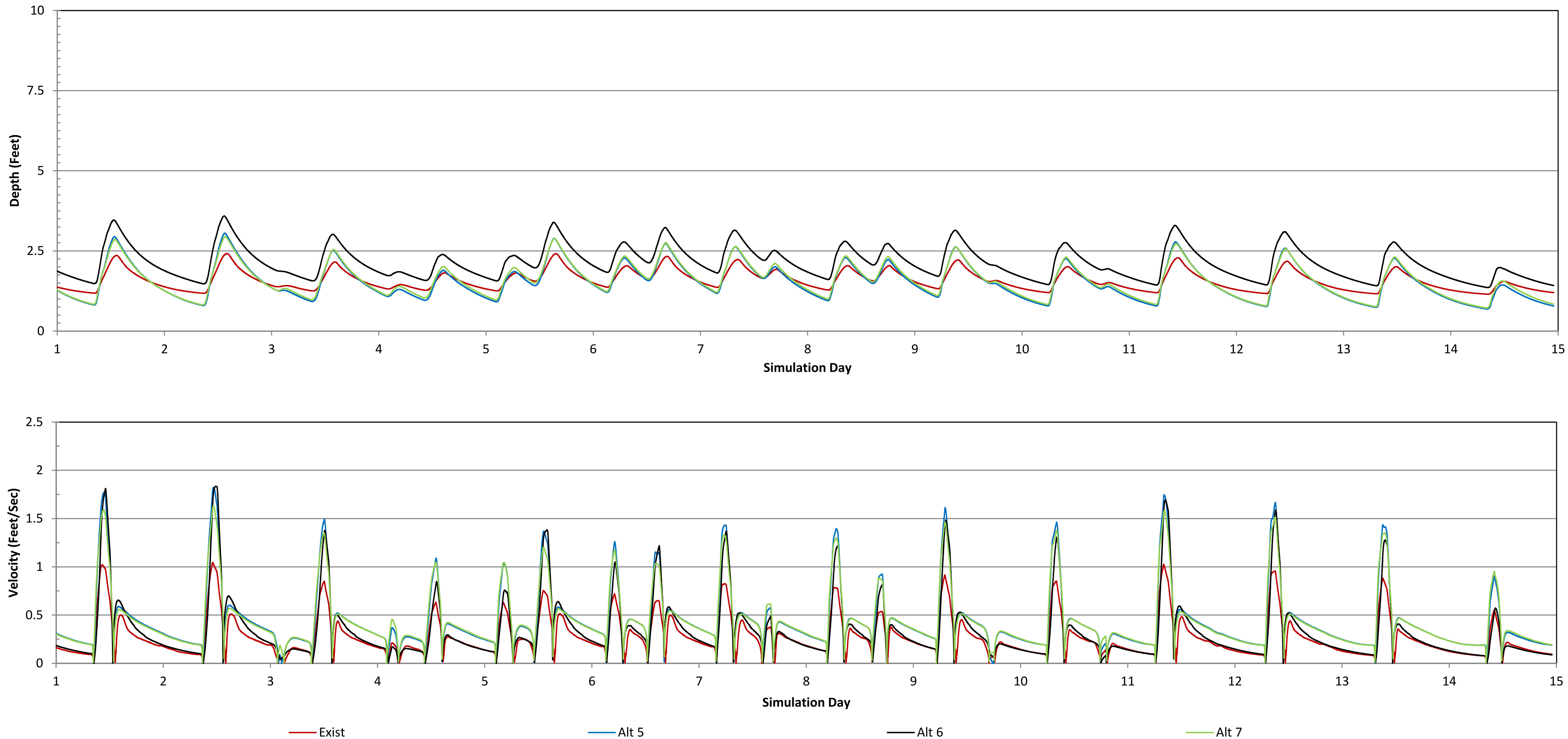
FIG. 51



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 4 - UPSTREAM OF DAYLIGHT CHANNEL

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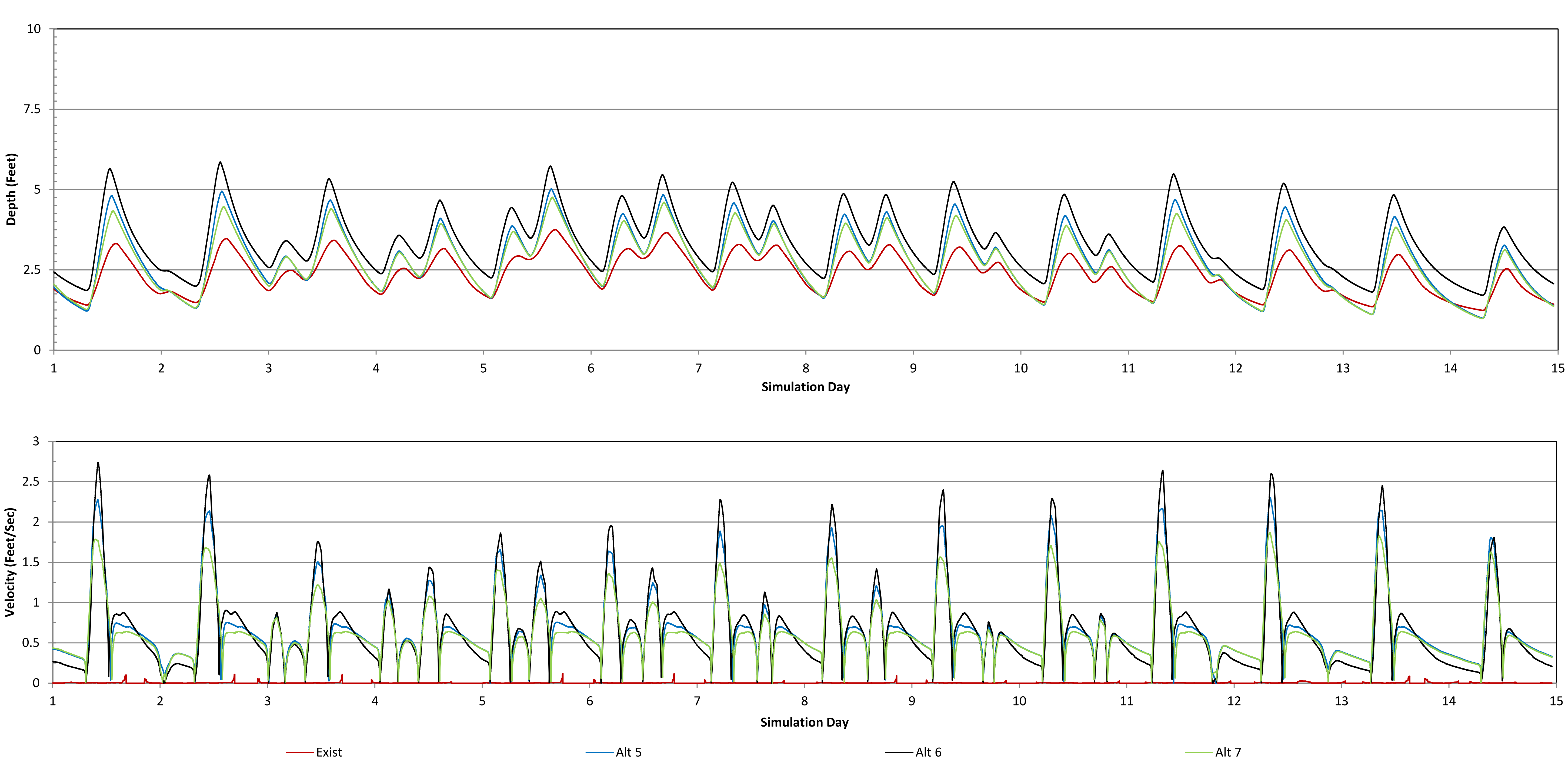
FIG. 52



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES

NODE 4 - UPSTREAM OF DAYLIGHT CHANNEL

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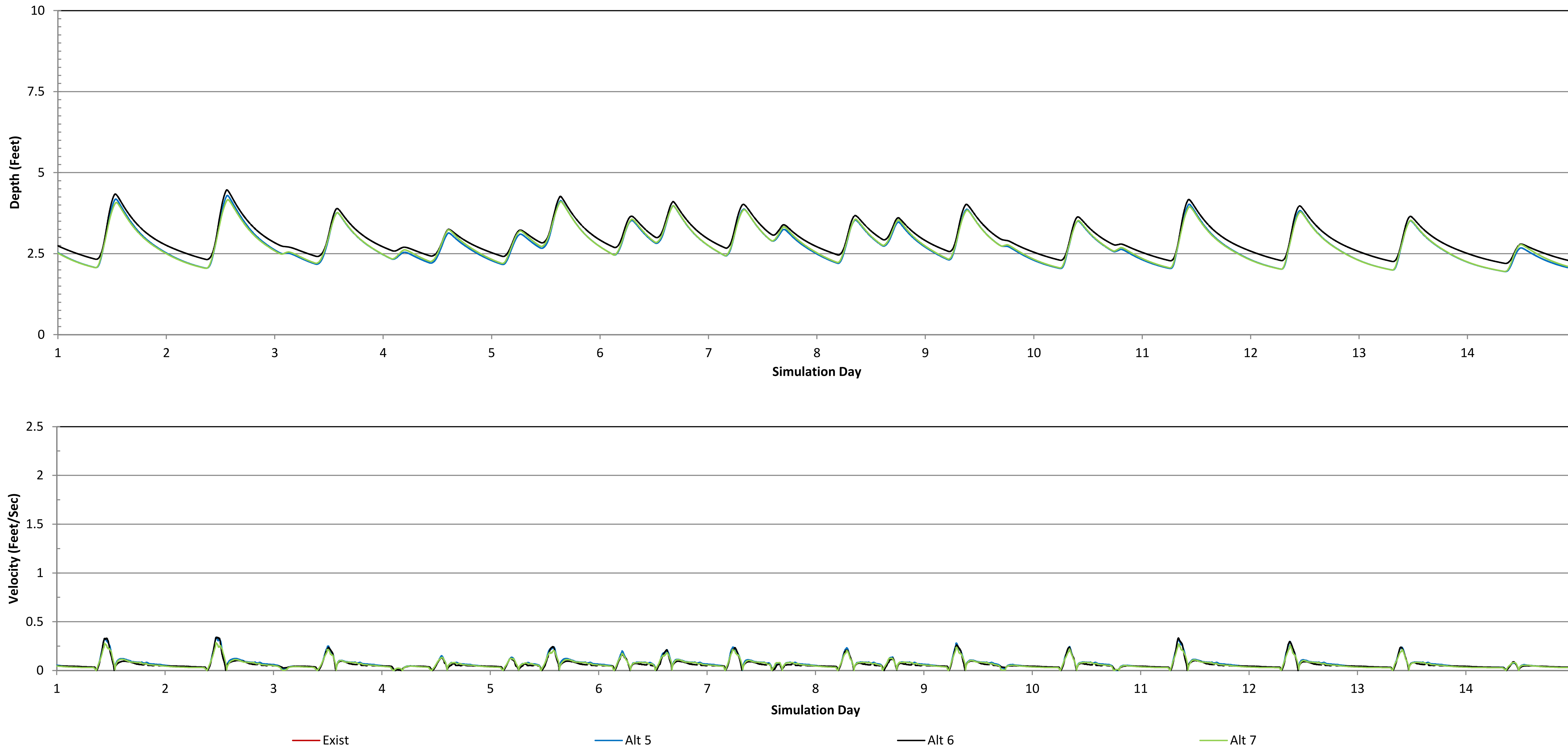
FIG. 53

Printed: 3-08-19 21:14 File: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Deliverables\FIGURES_POST_COMMENTS\[21-1-12588-050-FIGS46-XX.xlsx]Fig59_Node7SLR-



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 5 - CENTER OF MARSH

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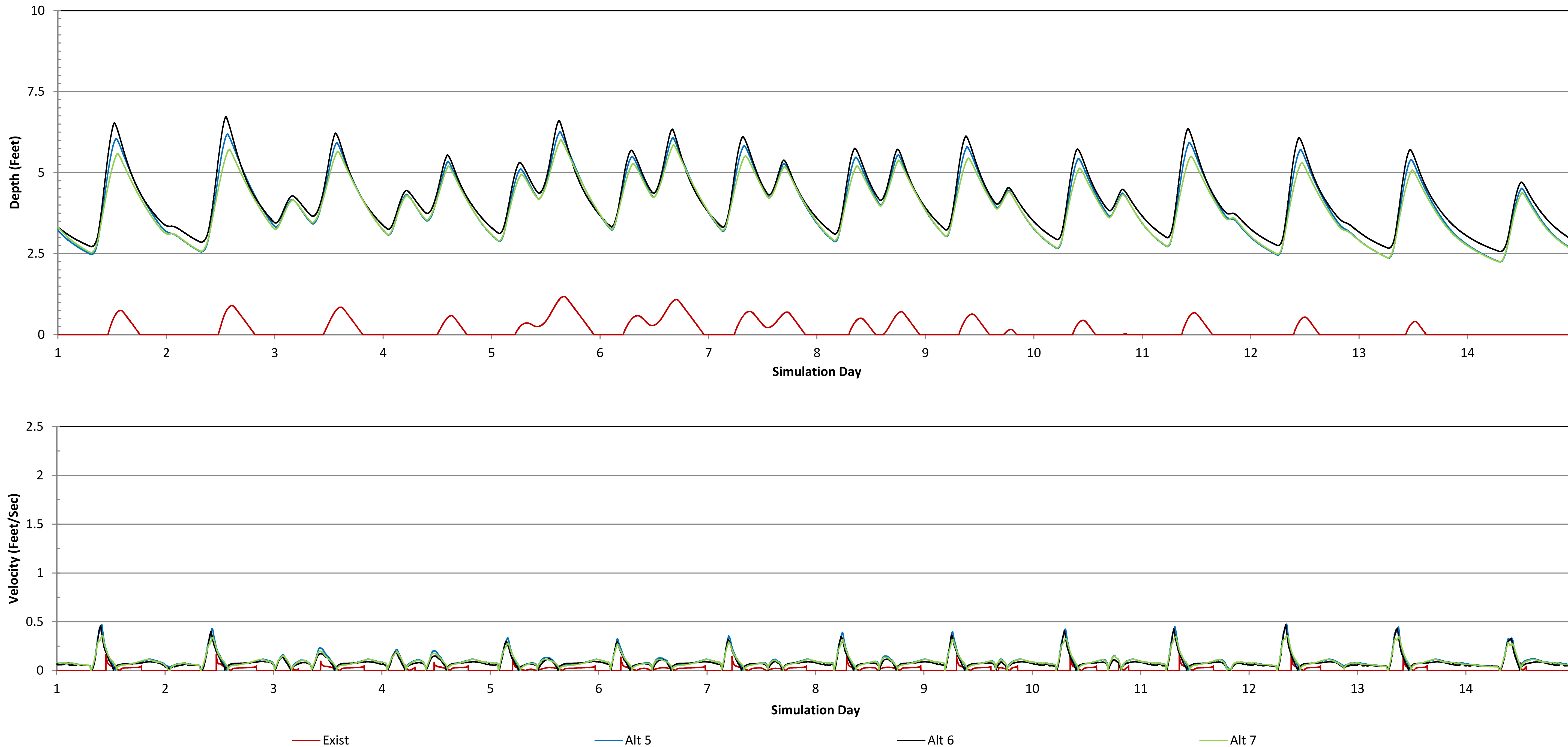
FIG. 54



Printed: 3-08-19 21:14 File: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Deliverables\FIGURES_POST_COMMENTS\[21-1-12588-050-FIGS46-XX.xlsx]Fig59_Node7SLR-

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES
NODE 5 - CENTER OF MARSH

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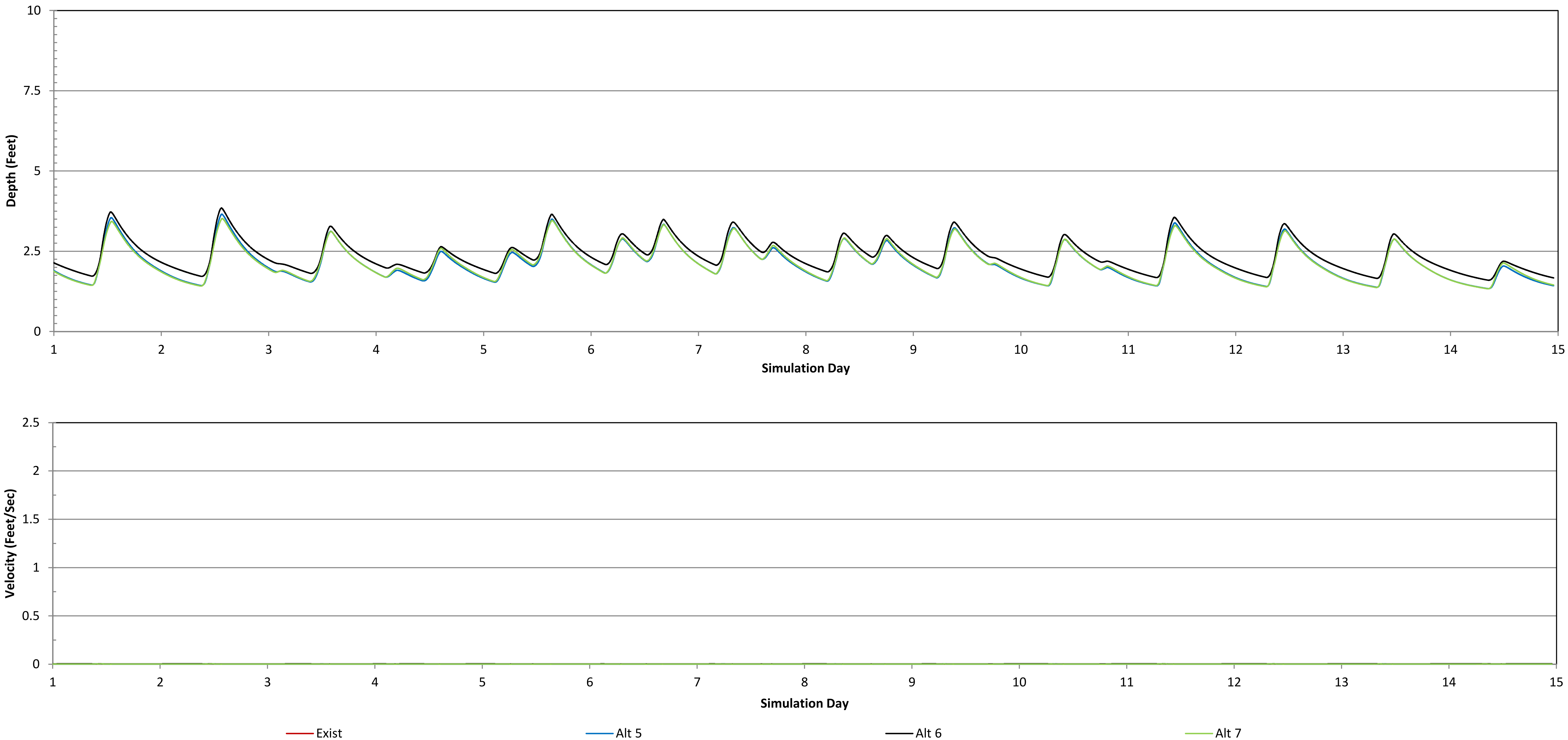
FIG. 55



Printed: 3-08-19 21:14 File: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\050 H&H FINAL ALTS - FLOODGATE\Deliverables\FIGURES_POST_COMMENTS\[21-1-12588-050-FIGS46-XX.xlsx]Fig59_Node7SLR-

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 6 - WILLOW CREEK DOWNSTREAM OF HATCHERY

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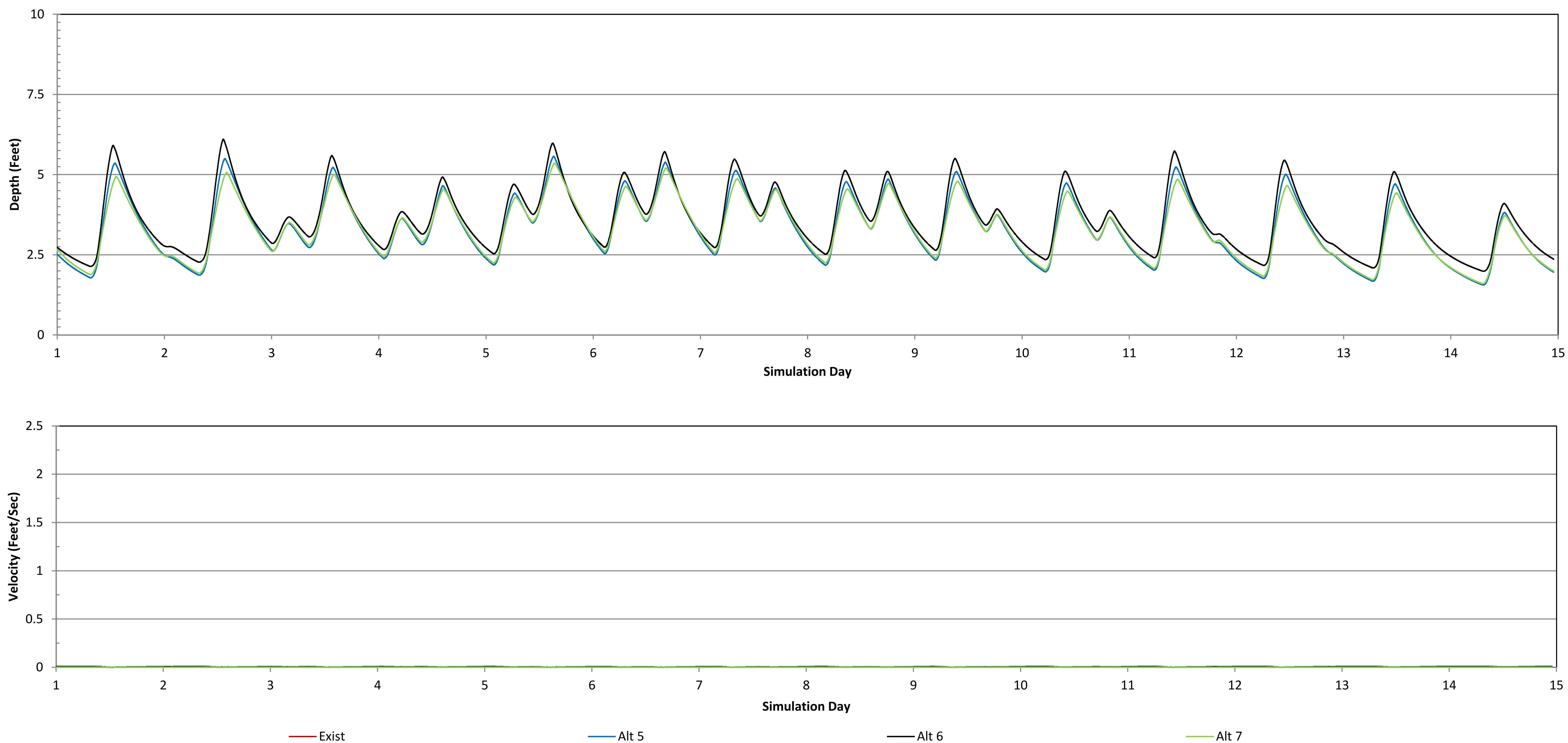
FIG. 56



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES
NODE 5 - WILLOW CREEK DOWNSTREAM OF

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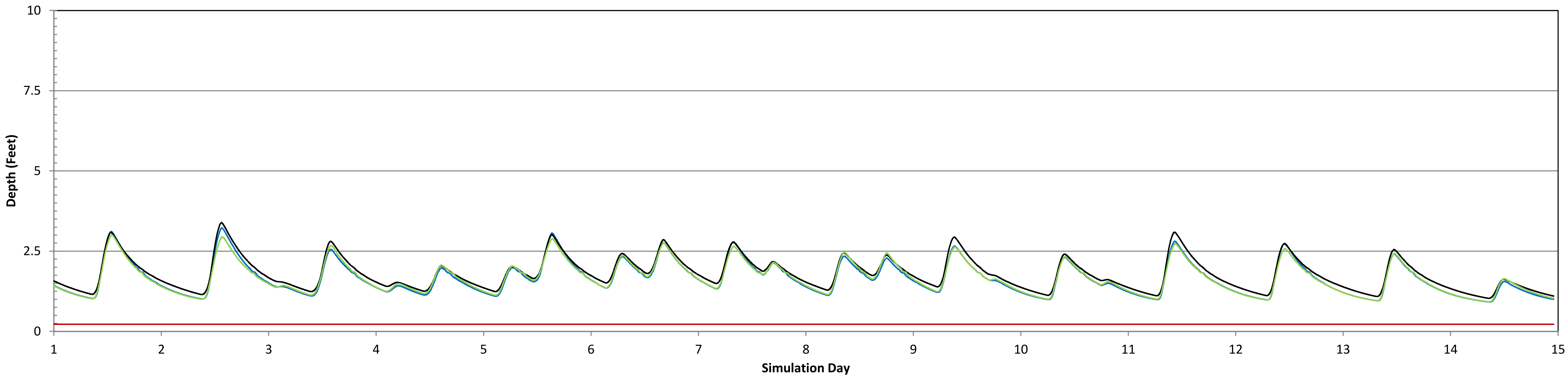
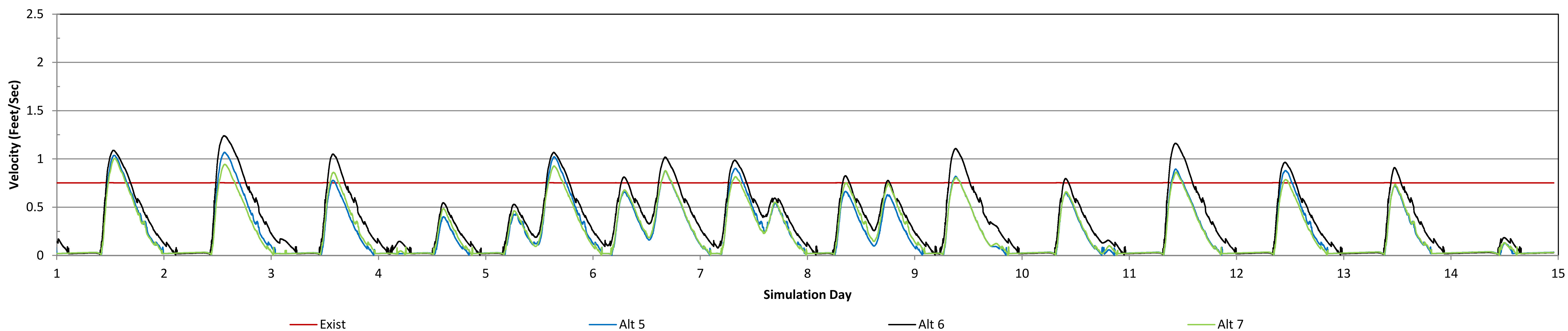
FIG. 57





WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE FLOOD DEPTHS AND VELOCITIES NODE 7 - SHELLABARGER CREEK DOWSTREAM OF SR 104

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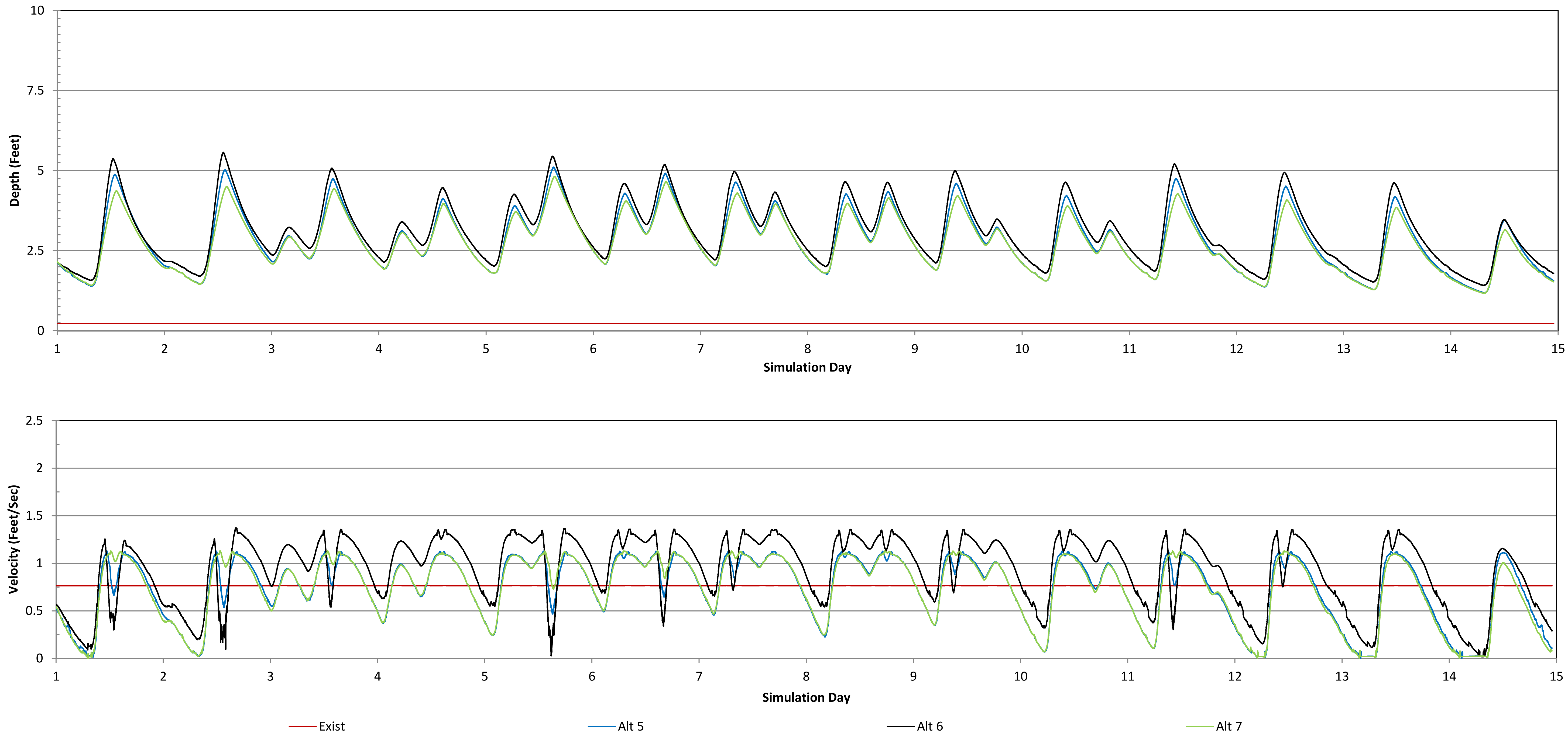
FIG. 58



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING EDMONDS, WA

LATE SPRING HABITAT FLOWS AND KING TIDE WITH SEA LEVEL RISE FLOOD DEPTHS AND VELOCITIES
NODE 7 - SHELLABARGER CREEK

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 59

IMPORTANT INFORMATION

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent

IMPORTANT INFORMATION

Important Information

About Your Geotechnical/Environmental Report

IMPORTANT INFORMATION

such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

IMPORTANT INFORMATION

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland